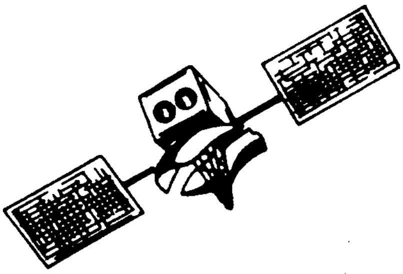
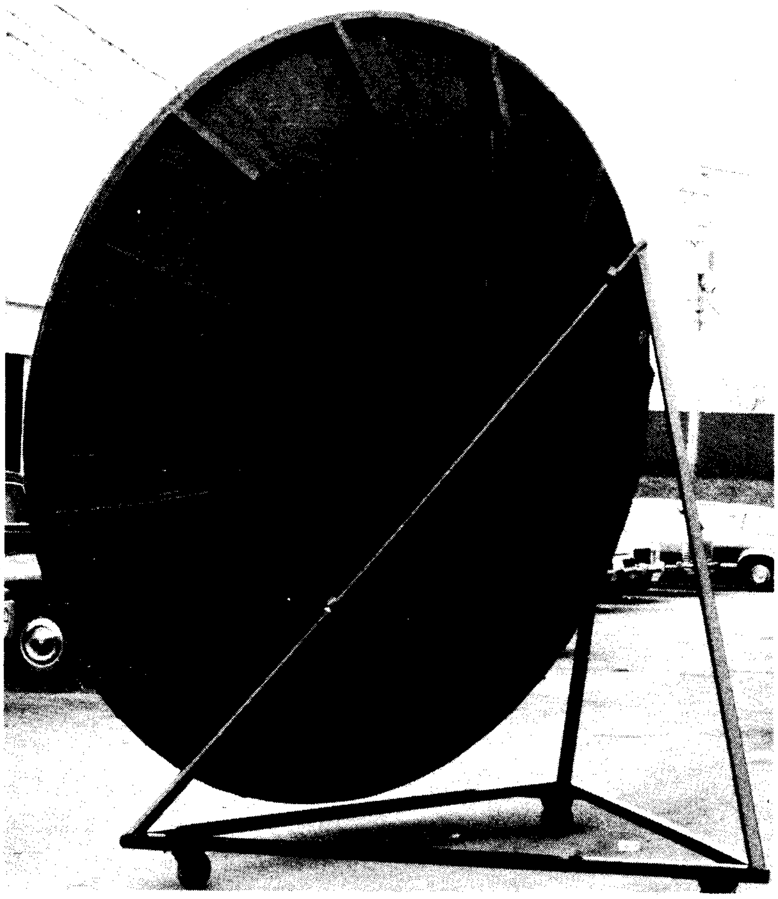


THE NELSON PARABOLIC
TVRO ANTENNA MANUAL



YOU CAN BUILD your own 10 or 12 foot (or larger) parabolic antenna utilizing modern metal plus fiberglass construction techniques; producing a professional quality antenna plus mount plus feed for between $300 and $500. PLUS - through this manual you can 'share' the mold form constructed for your own antenna and create a 'cottage-industry' business operation producing satellite antennas for distribution in your area.

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THE NELSON PARABOLIC TVRO ANTENNA MANUAL

...a Manual to allow you to design and build your own high-performance parabolic TVRO including feed and mount utilizing state-of-the-art fiberglass plus metal construction techniques. Literally, a 'blueprint' for creating your own single backyard antenna or to enter commercial production of these antennas for distribution in your region of the country.

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Nelson Ethier of Montreal, Quebec is a layman with no formal microwave training. He is however an excellent student of obscure textbooks and an avid do-it-himselfer with a flair for making difficult projects come out with precision. His experience includes not only the high-quality TVRO antennas described in this manual but also extends to ultra-low noise amplifier system experimentation developing noise temperatures in the 80 degree Kelvin range with off-the-shelf parametric amplifier parts. Surface accuracy to +/- 1/8th inch is assured by those who duplicate his plans in this manual and that says high performance for a minimum of dollars invested. He dedicates this manual and his own efforts to the memory of Arizonian Oliver Swan, the 'father' of innovative TVRO antenna technology for the low-cost terminal industry.

ACKNOWLEDGEMENTS: Belated thanks to Chris Schultheiss and Mike Jurgenliemk for their contributions of ideas and labour, without which the construction of the original test antenna would have been MUCH more difficult, and special thanks to Skip Amey and Carl Grube for their artwork and drawings which saved me a thousand words each! Lastly, mucho thanks to Dave Lester for his invaluable help with formulae and calculations.

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CONTACTING STT: For additional copies of this Manual ($30 each) or for a complete list of seven different low-cost satellite TV construction and operational manuals available from Satellite Television Technology; or to obtain information about subscribing to the monthly "**COOP'S SATELLITE DIGEST**", you may contact STT at P.O. Box G, Arcadia, Oklahoma 73007 or telephone 405-396-2574 between the hours of 9 AM and 4 PM central time.

FORWARD

A great way to get started in home satellite TV is by building your own parabolic dish. It is easy and economical, requiring no special tools or hard to get parts, and can be completed in your spare time in less than a week.

You will find the dish easier to build than a small boat. No electronic knowledge or microwave experience is necessary and the step-by-step instructions make this an excellent family project. The information supplied in this manual will also be valuable if you decide to custom design your own antenna. The manual supplies all the necessary information, drawings and pictures for building a ten foot dish, a twelve foot dish, and a twelve foot dish with shroud.

The dish will be impressive sitting in your yard. Building this professional looking antenna will boost your ego and fill you with a sense of pride and accomplishment. With proper care you will end up with a product as good as or better than what is currently available commercially.

Another incentive for building your own antenna is the time factor involved. If you start building your antenna the day your neighbor orders one from an antenna supplier, you will likely complete your antenna and have it up and working before your neighbor's dish even arrives in your city. Delivery in the TVRO business is quite poor and tends to average between 30 to 60 days from the order date. Moreover, many companies require a deposit of 30 to 100%.

Naturally the cost saving of building your own antenna is a large factor. The cheapest 12 foot fiberglass dish available at the time of printing is priced at $1200.00 with an additional $575.00 for an unmotorized mount. Add another $150.00 for a rotatable feed mount and shipping costs of between $150.00 and $600.00, depending on where you live, and the total cost of the dish comes to between $2,000.00 and $2,500.00. The more expensive dishes can cost up to twice as much. Furthermore, the price of fabricated dishes will tend to rise rather than fall due to increasing materials and shipping costs.

Building your own dish, however, will cost from $300.00 to $500.00 depending on your ability to obtain the raw materials at reduced prices or from salvage yards.

Since over half the time and expense of building the dish goes into fabricating the mold, even greater savings could be realized by getting a few friends together and building several dishes from one form. You could even set up a small cottage industry in your area building dishes for your local TVRO equipment supplier. The high cost of shipping these heavy, bulky antennas cross country makes building them in your own area a competitive enterprise.

It makes good sense to build your own dish even if you intend to buy the rest of the system. Performancewise your home-built dish will compare very favorably with the commercial product. Costwise you will be way ahead of the game!

PARABOLIC DISH DESIGN FOR TVRO

A parabolic dish antenna is an antenna of which the reflective surface has the configuration of a parabolic curve. When a parabolic surface is aimed at a distant signal source, the energy that strikes that surface is reflected to one point, known as the focus (illustration 1-a). The center of the dish is called the origin. A line from the origin to the focus will represent the sighting plane of the dish. A dish oriented so that a straight line will pass through the centers of the origin, focus and signal source is considered to be properly aimed (illustration 1-b).

The parabolic dish is the most popular type of antenna for use with the TVRO terminal. Most systems being sold employ this type of antenna. The large horn type of antenna is just too large at the 3.7 - 4.2 GHz bandwidth to be practical for private TVRO use. Stacked Yagis or Collinear array type U.H.F. / V.H.F. antennas do not have enough gain to merit serious consideration.

The elliptical or spherical reflector is the only other practical alternative. The main difference between the parabolic dish and the spherical reflector is the method of signal collection. The spherical reflector deflects the incoming signal to a focus point which is not usually in line with the origin and signal source (illustration 1-c). The common method of mounting the spherical reflector is to secure the surface in a fixed position and move the feedhorn to focus the dish on the various satellites.

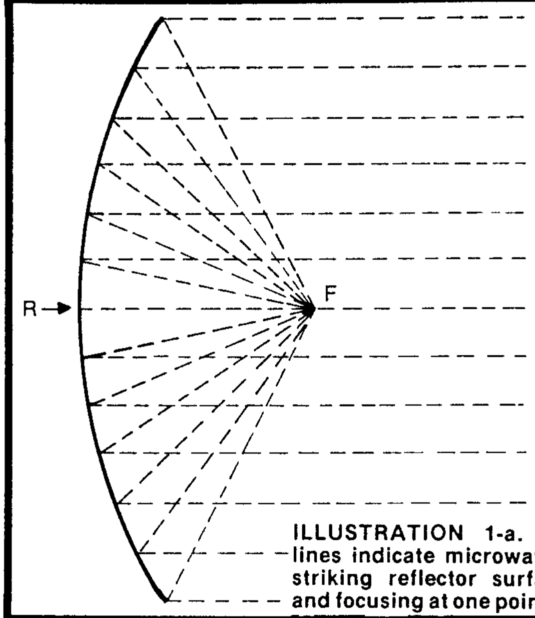


ILLUSTRATION 1-a. Dotted lines indicate microwave path striking reflector surface [R] and focusing at one point [F].

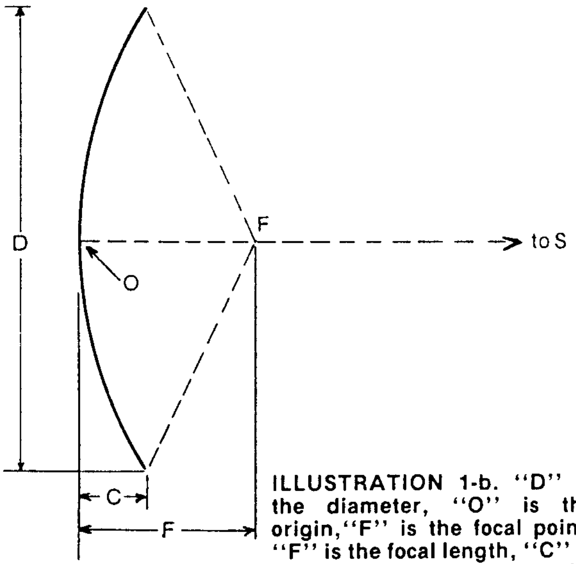
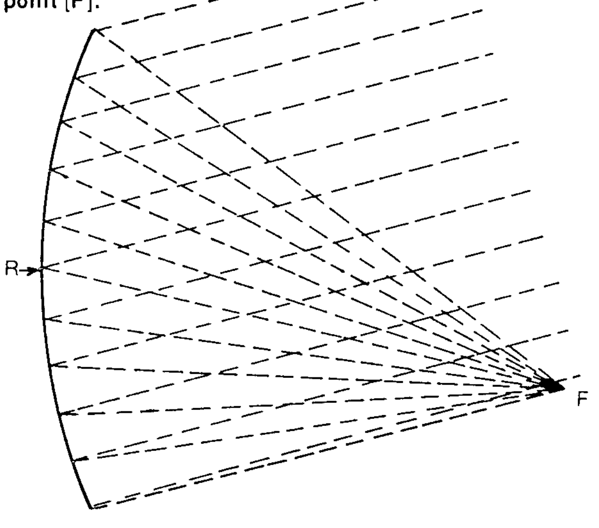


ILLUSTRATION 1-b. "D" is the diameter, "O" is the origin, "F" is the focal point, "F" is the focal length, "C" is the depth of the dish, and "S" is the signal source.

The focus point of the parabolic dish never changes. The entire reflector surface rotates to track the various satellites. At first thought it would appear to be much easier to move a small feedhorn rather than a large parabolic dish, and the mount for the elliptical reflector would seem to be easier to construct than the mount for a parabolic dish. This is not necessarily true and this manual describes (chapter 6) a polar mount that is very simple and easy to construct. It allows easy changing of the dish position for tracking satellites. In fact, the dish moves in one plane and will track all the satellites. This method of mounting also lends itself to motorizing the entire mount so that every function of satellite tracking can be by a machine much like a home TV antenna rotor.

Another advantage of the parabolic dish is that it offers

ILLUSTRATION 1-c. Shows the spherical or elliptical antenna. The dotted lines indicate the microwaves striking the reflector surface [R] and focusing at the point [F].



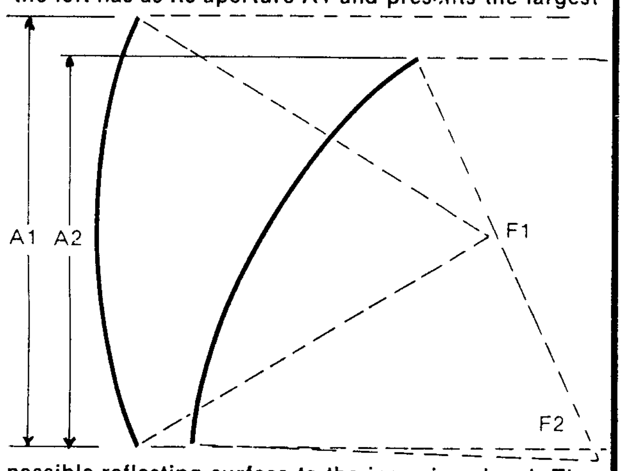


ILLUSTRATION 1-d. Shows two spherical antennas at different angles to the incoming signals. The reflector at the left has as its aperture A1 and presents the largest possible reflecting surface to the incoming signal. The antenna at the right has a reflector surface at a lower angle.

the **entire** surface to the incoming signal. The gain of the spherical antenna, however, diminishes as the angle between the incoming signal and the feedhorn increases because the aperture simultaneously decreases (illustration 1-d).

Generally speaking, the higher the gain of an antenna the narrower the beamwidth will be. To understand this statement we will think in terms of transmitting capability or dB gain of an antenna. There is no magic in understanding antenna gain. The gain of an antenna can only be changed by focusing the power coming from the antenna into a single direction. The increased gain can be thought of much like the beam coming from a light source: the more narrowly the beam of light is focused, the farther the beam will travel. A large dish will focus the beam more narrowly than a small dish, producing a smaller beamwidth and more gain.Thus if we consider that the receive and transmit gain of the antenna are the same, we can assume that a larger antenna focuses on a much smaller portion of the sky than a smaller one.

Along with the benefit of increased gain, the larger antenna with its narrower beamwidth has the advantage of lowering the noise level. This is because there is noise present in the sky and the more sky the antenna focuses on the more noise it will receive.

In microwave, the system of noise measurement commonly used references the noise level to absolue 0; or -273.18 degrees C. This system, called the Kelvin method, uses the term "degrees K". The reason for using absolute zero as a reference point is because of the direct relationship between temperature and noise. **At absolute zero there is no noise** since all molecular motion stops. The dB scale of noise measurement needs to have a reference point and because we are talking about such low levels of noise the degree Kelvin is the most practical method of expressing it. Let us take an example of this. A low noise amplifier is rated at 120°K or 1.5 dB at 20° C. This means that the LNA adds 1.5 dB or 120°K of noise to the signal passing through it. If 40°K more noise were added to this signal by the antenna we would **add the two noise figures** (40°K from the antenna and 120°K from the LNA) to give a total of 160°K for our system noise figure at the receiver input without having to calculate voltage ratios. Below is an abbreviated conversion chart.

80°K - 1.1 dB
100°K - 1.3 dB
120°K - 1.5 dB
150°K - 1.8 dB
180°K - 2.1 dB
260°K - 2.8 dB

The formula for converting degrees K to dB is:

$$N = 10 \log \left(\frac{T}{290} + 1 \right)$$

where N = noise in dB
T = degrees K

The gain ratio of an antenna means the antenna will show increased signal over the use of an isotropic source or a common dipole in free space. An isotropic source is a point source antenna which radiates equally in all directions. Since no real antenna does this, the isotropic radiator is a mathematical ideal used as a reference point for gain. A real antenna used for this purpose is a common dipole type antenna sitting in free space. The dipole, because it does show some directionality, **has gain over** the mathematical isotropic radiator. The terms dBi (isotropic radiator) and dBd (dipole in free space) are used to describe these antenna. If the term used does not have small "i" or "d" following the dB, as it should have, it is assumed that the reference is to the isotropic radiator.

To calculate the gain of an antenna we must first know the area of its aperture and its wavelength. We will use a 12 foot dish at the frequency of 3.95 GHz as an example. Since the aperture area is the area of the circle described by the perimeter of the antenna (not the surface of the dish), we can easily calculate it using the following formula.

$$A = \pi r^2$$

$$= \pi \times 36$$

$$= 113.1 \text{ sq. ft.}$$

where A = area of aperture

r = radius of aperture

$\pi = 3.14$

Thus the aperture area of a 12 foot dish is 113.04 sq.ft.

Next we must find the antenna's wavelength. The formula is:

$$\lambda = \frac{984}{f}$$

λ = wavelength in feet*

f = frequency in megahertz

***This formula is used for expressing the wavelength in feet only.**

$$\lambda = \frac{300}{f}$$

will express the wavelength in meters.

The frequencies at which satellites transmit encompass 500 MHz. They extend from 3.7 GHz to 4.2 GHz. GHz are converted to MHz by multiplying by 1000. For our example we will use the mid-point of the band, 3.95 GHz.

$$\lambda = \frac{984}{3950} = .25 \text{ ft.}$$

Now we have the information needed to calculate the gain.* Here is the formula for gain calculation.

$$G = 10 \log \frac{7(A)}{\lambda 2}$$

$$10 \log \frac{7 \times 113.04}{.25^2}$$

$$10 \log \frac{791.28}{.0625}$$

$$10 \log \ (12660)^{**}$$

$$= 10 \times (4.10)$$

$$= 41.0$$

where G = gain in dB

A = area of the aperture

λ = wavelength

***The assumption is that the edges of the dish are illuminated to a point 10 dB down from the center of the dish.** (see chapter 5 for feedhorn illumination) The dish is also presumed to work at the 'standard' efficiency level of 55%.

****12660 is the actual gain figure before conversion to dB.**

Another formula for calculating gain involves using the percentage of efficiency.

$$G = 10 \log \frac{4\pi \ (A)}{\lambda 2} \times E$$

$$= 10 \log \frac{4\pi \ (113.04)}{\lambda 2} \times \frac{55}{100}$$

$$\frac{4 \times 3.14 \times 113.04}{.0625} \times .55$$

$$= \quad 10 \log (12500)$$

$$= 10 \times 4.10$$

$$= 41.0 \text{ dB}$$

where G = gain in dB

A = area of aperture

λ = wavelength

E = percentage of efficiency

π = 3.14

Chapter 5 will discuss illumination and feedhorn design. The feedhorn will be factor in determining over-all gain. Using the above formula we will be able to determine gain at various percentages of efficiency.

We can calculate the beamwidth of an antenna with this very simple formula.

$$B = \frac{4 \times \lambda}{D}$$

where B = beamwidth

λ = wavelength

D = diameter of the aperture in feet

The proper coverage of noise would require a separate chapter. In the TVRO system there are many sources of noise but we will concern ourselves here only with noise produced in the sky and from the ground.*

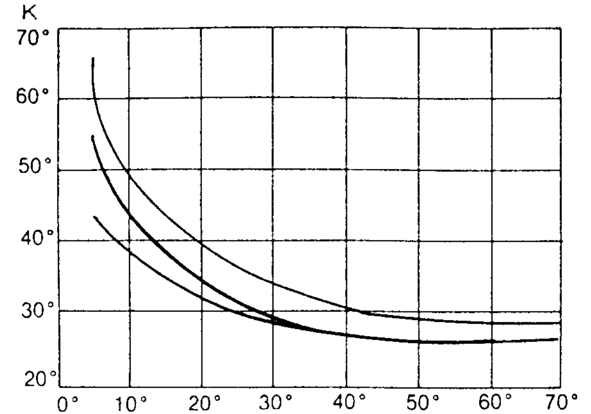
We have no control over the types of noise produced in the sky. These include cosmic, man-made, atmospheric noise and noise caused by absorption of the signal by oxygen and water vapor. Cosmic noise is not really a factor at frequencies above 1.5 GHz and can usually be disregarded. Man-made noise is a problem only if someone close by is transmitting at the satellite's frequency. In suburban or rural areas this problem would be a very rare but in large cities it could be a problem. The best way to check an area is to look around for microwave antennas and inquire about the frequency being used.

Atmospheric noise is not really a problem at frequencies above 300 MHz. There is also noise from the atmosphere caused by signal absorption by water vapor and oxygen. The noise occurs when the microwave signals strike the atmosphere and are attenuated. This attenuation causes the signal energy to be converted into noise during the absorption process. The noise level can range from 10 to 80 degrees K depending on the amount of water vapor present in the atmosphere. This amount of noise could cause problems for a marginal system.

Another source of noise is the earth itself. This noise increases as the look-angle of the dish decreases. In other words, the closer to the ground the antenna has to look to see the satellite the worse the noise will be, but the noise will diminish as the gain of the antenna increases. To understand why this happens we must remember that a larger antenna has more gain in the beamwidth and less outside the beamwidth than does a smaller antenna. Therefore, the gain on the sides of the larger antenna will be less than that of a smaller one. Since it is gain outside the beamwidth which picks up ground noise, the larger antenna will pick up less of it. Ground noise is more of a problem in Northern and Eastern areas where the look-angle must fall below 12 degrees. (For the increase in ground noise see **graph 1-e**.)

If a system must be used at look-angles below 12 degrees a shroud to reduce system noise could be considered. The shroud is a shield placed around the circumference of the dish. The shroud is a shield placed around the circumference of the dish (illustration 1-f). Unfortunately, there are sound arguments for and against meaningful reduction of noise by the addition of a shroud.

***See chapter 2 for a discussion of other types of noise.**



TOPLINE - 10' dish / MIDDLELINE - 12' dish / BOTTOMLINE - 12' dish with shroud

GRAPH 1-e

Noise temperature is difficult to calculate without expensive test equipment (anechoic chamber and calibrated test equipment). Even with this equipment, readings taken under actual test conditions at low angles can vary as much as 10° per hour making accurate measurements in the field nearly impossible.

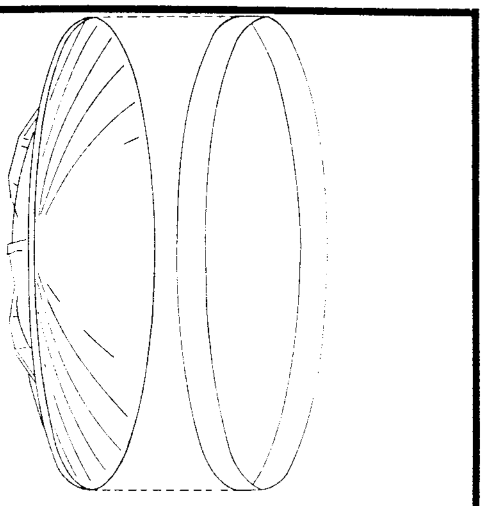


ILLUSTRATION 1-f. Shows a parabolic dish with a shroud on the right hand side. A shroud is commonly a 6" to 8" ring of microwave absorptive material. The shroud is shown exploded from the dish, but is always mounted attached to the dish at the circumference-edge.

The f/D ratio of a dish is the focal length, the distance from the focus to the origin, **(illustration 1-b) divided by** the diameter of the dish. Thus a twelve foot dish with a focal length of 4.5 feet has an f/D ratio of .375. An antenna with an f/D **below** .135 has a very **steep** angle of illumination. An antenna with an f/D of .25 has its focus on the same plane as the edge of the dish. These dishes with very low f/D ratios require special feeds that make them difficult to home build. A common feed for them is the Cassegrain type which reflects the signal off a smaller reflector placed in front of the focal point thus changing the angle of reflection to an easier one to feed. The reason for using **deep** dishes is that they have better noise rejection properties than the shallow types because they minimize side lobe gain (gain outside the beamwidth).

Shallow dishes, those with f/D ratios **over .5**, have more actual gain than the deeper dishes but they also have higher ground noise problems.

When designing your own dish it becomes very important to take into account the dish's f/D ratio and the look-angle at which the dish will be used. The 12 foot dish in this manual has an f/D ratio of 3.75 which gives an antenna with good side lobe noise rejection and standard Newtonian feed capability. A Newtonian feed is a feed placed **at** the focus.

This 12 foot dish with its .375 f/D is optimum for the low look-angles of Northern and Eastern North America. Adding the shroud to it may additionally make it function better at lower look-angles.

The ten foot dish is designed with an f/D ratio of 4.5 to give a flatter dish. This dish will have a little more gain than the deeper dishes of the same size but will also have higher noise levels. Therefore, this dish is best suited for the Mid and Southwestern regions.

To realize how accurate a dish must be we must first look at the consequences of inaccuracy. Accuracy is determined by how closely the dish follows the parabolic form. Over a **small** area of the dish deviations of up to 3/8 inch will not affect the gain very much. Screw heads, bumps, small joining strips (like the ones used in dishes described in this manual) affect the gain very little. However, deviations of as little as 1/8 inch can reduce the gain if they occur over a **large** area of the dish. They can reduce the gain by as much as 1 dB. The accuracy requirements increase as the frequency rises. For 8 GHz they will double. These accuracy requirements should not worry the antenna builder, however, as they are fairly easy to achieve for the 4 GHz band.

A parabolic template can be used to check a dish for accuracy. This is a plywood plate on which the proper parabolic curve has been accurately cut. The template is held into the dish and rotated so that any gaps or bumps on the surface can be noted.

The dish surface must be reflective of microwave frequencies. Most common metal such as brass, copper, aluminum, steel and silver will reflect microwaves. Wire mesh can also be used if the mesh is fairly tight. Mesh made with thin wire, such as window screening, however, may have less gain than mesh made with thick wire. Some manufacturers make dish surfaces reflective by using special guns to spray them with hot droplets of aluminum. **Solid** metal surfaces are a good way of assuring maximum microwave reflectivity and gain.

There are many different methods for constructing parabolic dishes. One type of dish is a superstructure of radial ribs covered with wire mesh. This type of construction is popular for very large dishes to counteract the enormous pressures of wind loading. There is also a type of construction using the spinning process to produce the entire dish giving it a solid reflector, usually aluminum. There are also many varieties of petal type dishes with the reflector surfaces constructed from aluminum or steel petals. The petals are either stamped out with the parabolic contours built in or are cut out of flat stock and formed around the outside ribs.

With fiberglass construction the antenna gets its strength from fiberglass ribs built into its back. Because fiberglass is non-reflective the surface must be made so. This surface can be produced in the dish by building a wire mesh into the dish, by coating the outside using a metalizing process or by molding an aluminum surface onto the fiberglass.

The construction method used in this manual employs a solid aluminum reflector surface with a fiberglass backing. This produces the lightest possible dish with the best type of reflector surface.

The formula for determining the parabolic curve for a dish is expressed in the common terms when y is a chosen value, y will equal the chosen value multiplied by a constant and the square root taken of the answer. **The factors that make up the constant are functions of the focal length and diameter.** If the diameter and focal length are known you have all the information necessary for using the formulas.

$$y2 = 4D \times \left(\frac{f}{D}\right)$$

or

$$y = \sqrt{4D \times \frac{f}{D}}$$

or

$$y^2 = 4f \times D$$

where y has both positive and negative values
D is the diameter of the dish
f is the focal length

All these formulas will give the same result. **To find some typical values** for a dish with a diameter of 12 ft. and an f/D of .375 we will use the following formula. All linear measurements will be in inches.

$$x = \frac{y^2}{4D(f/D)}$$

$$x = \frac{y^2}{4 \times 144 \times .375}$$

$$= \frac{y^2}{216}$$

Table B gives the coordinates for x where y is moved in increments of .5 inches. These increments provide enough points to trace the parabolic curve to within 1/16 of an inch freehand or 1/100 of an inch using a french curve.

$$x = \frac{y^2}{4D\ (f/D)}$$

$$\text{10 foot dish } x = \frac{y^2}{4 \times 10 \times .45}$$

$$\text{12 foot dish } x = \frac{y^2}{4 \times 12 \times .375}$$

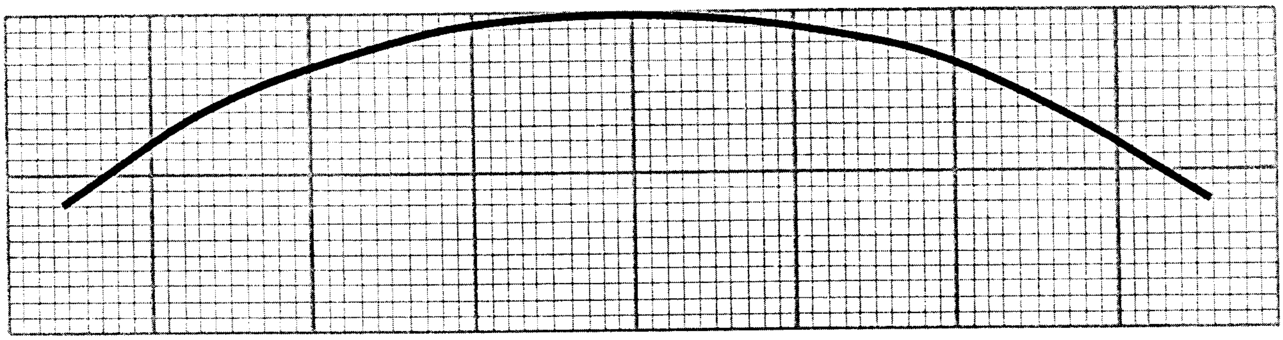
$$= \frac{y^2}{18}$$

For these examples the diameter is measured in feet.

TABLE A

Dish Diameter	Aperture In Sq Ft	Bandwidth In Degrees	Noise Figure* At 70° Look Angle	Noise Figure* At 12° Look Angle	Frequency	Gain In dBi**
8 ft.	50.26	2.0	32°	70°	3.7 GHz	37.0
					3.95 GHz	37.5
					4.2 GHz	38.1
10 ft.	78.54	1.6	29°	46°	3.7 GHz	39.0
					3.95 GHz	39.5
					4.2 GHz	40.0
12 ft.	113.09	1.3	26°	40°	3.7 GHz	40.5
					3.95 GHz	41.0
					4.2 GHz	41.6
15 ft.	176.71	1.1	24°	36°	3.7 GHz	40.5
					3.95 GHz	41.0
					4.2 GHz	41.6
12 ft. with shroud	113.09	1.3	26°	**37°**	3.7 GHz	42.5
					3.95 GHz	43.0
					4.2 GHz	43.5
18 ft.	254.47	.9	23°	34°	3.7 GHz	44.1
					3.95 GHz	44.6
					4.2 GHz	45.1
20 ft.	314.16	.8	22°	33°	3.7 GHz	45.0
					3.95 GHz	45.5
					4.2 GHz	46.0

*Noise figures are estimates.
**55% efficiency is assumed.



Lay out a graph to show your anticipated curve for a dish on a single piece of graph paper. On the graph below each small square equals 2 inches. The graph uses the values given on Table B.

GRAPH 1-g

TABLE B

+ - y	$y^2/216$	+ - y	$y^2/216$	+ - y	$y^2/216$
0	0	12.0	.67	24.0	2.67
.5	.00	12.5	.72	24.5	2.78
1.0	.00	13.0	.78	25.0	2.89
1.5	.01	13.5	.84	25.5	3.01
2.0	.02	14.0	.91	26.0	3.13
2.5	.03	14.5	.97	26.5	3.25
3.0	.04	15.0	1.04	27.0	3.38
3.5	.06	15.5	1.11	27.5	3.50
4.0	.07	16.0	1.19	28.0	3.63
4.5	.09	16.5	1.26	28.5	3.76
5.0	.12	17.0	1.33	29.0	3.89
5.5	.14	17.5	1.42	29.5	4.03
6.0	.17	18.0	1.5	30.0	4.17
6.5	.20	18.5	1.58	30.5	4.31
7.0	.23	19.0	1.67	31.0	4.45
7.5	.26	19.5	1.76	31.5	4.59
8.0	.30	20.0	1.85	32.0	4.74
8.5	.33	20.5	1.95	32.5	4.89
9.0	.38	21.0	2.04	33.0	5.04
9.5	.42	21.5	2.14	33.5	5.20
10.0	.46	22.0	2.24	34.0	5.35
10.5	.51	22.5	2.34	34.5	5.51
11.0	.56	23.0	2.45	35.0	5.67
11.5	.61	23.5	2.56	35.5	5.83
36.0	6.00	47.5	10.45	59.5	16.39
36.5	6.16	48.0	10.67	60.0	16.67
37.0	6.33	48.5	10.89	60.5	16.95
37.5	6.51	49.0	11.12	61.0	17.22
38.0	6.68	49.5	11.34	61.5	17.51
38.5	6.86	50.0	11.57	62.0	17.80
39.0	7.04	50.5	11.81	62.5	18.08
39.5	7.22	51.0	12.04	63.0	18.38
40.0	7.40	51.5	12.28	63.5	18.67
40.5	7.59	52.0	12.52	64.0	18.96
41.0	7.78	52.5	12.76	64.5	19.26
41.5	7.97	53.0	13.0	65.0	19.56
42.0	8.17	53.5	13.25	65.5	19.86
42.5	8.36	54.0	13.50	66.0	20.17
43.0	8.56	55.00	14.00	66.5	20.47
43.5	8.76	55.5	14.26	67.0	20.78
44.0	8.96	56.0	14.52	67.5	21.09
44.5	9.16	56.5	14.78	68.0	21.40
45.0	9.38	57.0	15.04	68.5	21.72
45.5	9.58	57.5	15.31	69.0	22.04
46.0	9.80	58.0	15.57	69.5	22.36
46.5	10.01	58.5	15.84	70.0	22.68
47.0	10.23	59.0	16.12	70.5	23.01
				71.0	23.34
				71.5	23.66
				72.0	24.00

This table is the one you will need to build the 10 foot dish with a .45 f / D ratio and the 12 foot dish with a .375 f / D ratio. The chart can be used for both dishes because they each have a focal length of 4.5 feet.

CHOOSING YOUR ANTENNA TO SUIT YOUR NEEDS

Several factors produce good picture quality in a TVRO system, but we will only concern ourselves with the LNA and antenna combination. Some assumptions must be made in selecting these. The main assumption is the CNR (C/N ratio or carrier to noise ratio) a receiver must have to produce the picture quality that **you** require. Also, you must estimate the amount of noise your antenna site will have. The power being delivered to your site by the satellite transponder that you are interested in must be gauged by the advertised EIRP of the satellite companies. These figures are only estimates and are seldom backed up by tests. Finally you will have to estimate your dish gain.

Take heart and bolster your pioneering spirit. Many, armed with the same knowledge you will have, have produced excellent results. The estimates we are going to make are very educated guesses based on lots of good theoretical formulas that have been around for years. We will temper all this theory with a little experience from all those who have ventured before us. The chances of good results are in your favor.

Perhaps someday we will have reliable test reports on all the equipment being offered by TVRO suppliers, but until then we will have to put up with estimates, word of mouth, written reports, our own experience and advertised information from companies supplying hardware. Therefore, if we calculate the amount of gain we require, estimating all the factors affecting gain and noise, and add a margin for inaccuracies, we can be reasonably sure of success.

For all those who are already sick of the math and theoretical design information, by all means skip to the end of the chapter and get the summation from the chart (**table 2-a**).

CNR ratio is simply the difference between the carrier level and the noise level present where the carrier level is measured without noise present and the noise level is measured without the carrier present. Therefore, the CNR produced by an antenna and an LNA is a figure in dB showing **how much the carrier level exceeds the noise level**. A CNR of "O" would indicate that the noise and the carrier are at the same level or that no signal could be seen above the noise, although signal **may be present** up to the level of the noise.

CNR = LNA input (in dBw) - LNA input noise (in dBw)

To find the CNR we must know several terms to calculate the signal and noise input to the LNA.

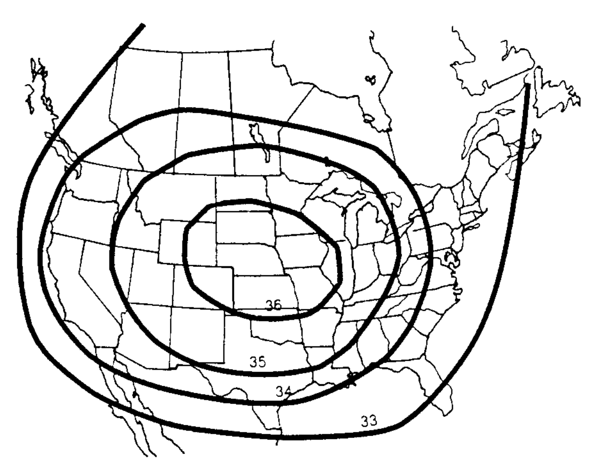
EIRP is the advertised radiated power of the satellite provided by the manufacturer or operator. For calculating a sample CNR we will use the RCA F1 satellite. This is the most popular of all the satellites and has the most programming of interest concentrated in its transponders. It is also one of the most difficult to receive, especially for the eastern United States and Canada. The highest concentration of its power is in the US Mid-west, falling about one dB for the Southwest US, the West Coast of the US, the Northwest US, and the Mississippi River region of the Central US. The East Coast of the US may be **another** dB down with portions of Florida and the Northeast US even lower. Canada, where look angle permits, is commonly three dBw down except for the southwest which is only 2 dBw down. The original satellite footprints called for much stronger signals than were later delivered. Test results placed the received signals more than one dB down from those advertised on the EIRP dBw Contour Map. This is one case where there **are** test results which provide better information than theory. The figures for our calculations are taken from EIRP test cases (see map: **Illustration 2-a**).

To calculate path loss we will use the formula for calculating path loss between two isotropic radiators.

Path Loss = 37 + 20 log f + 20 log d
where 37 is a constant
f is the frequency in megahertz
d is the distance in miles

The frequency we will use for our example is 3.95 GHz, the middle of the satellite transponder band. The distance we will use will be 26,000 miles, the distance the satellite signal must travel to strike the middle of the US. For those who like their figures to be nothing short of theoretical perfection, dust off your trig and figure out the distance of the satellite to your own city.

$$\begin{aligned} \text{Path Loss} &= 37 + 20\log f + 20\log d \\ &= 37 + 20\log 3.950 + 20\log 26{,}000 \\ &= 37 + 71.93 + 88.29 \\ &= 197.22\ (\text{dB}) \end{aligned}$$



This map shows the level of R.C.A. Satcom I as measured after the bird was up and transmitting. The figures were obtained from ground tests.

Illustration 2-A

The difference **across** the US because of **increased** distance from the satellite will vary **less than .5 dB**.

The proper way to calculate the CNR is to take all parameters into account. The signal level is taken from the Bird EIRP footprint chart or from the tested EIRP for your area. We then reduce this signal level by the path loss of the signal on the way to the antenna. Then we add the gain of the antenna taken from the standard gain formula (see **table 1-a**). If you are a real nut for accuracy you can adjust the gain of our dish by the factor of our dish loading (see Chapter V). All our terms so far have been in dB and represent our total carrier signal as seen **at the mouth** of our LNA without any noise added. Now we must add up the **total noise** and convert it into dB so that we can **subtract it** form our first total.

The noise figure of the antenna represents the noise that our antenna sees as it looks into the sky. Because the noise level rises as the look-angle fo the antenna decreases, it is a good idea to use the antenna temperature of the look-angle from your site as you focus on the satellite you most want to receive. Look again at **graph 1-e** for the noise at different angles and see Chapter VI to calculate the angle of the antenna to the ground for your locale when the antenna is aimed at various satellites.

To the antenna noise we add our noise from the LNA, a figure usually obtained from the manufacturer's specs. We multiply this total by Boltzman's Constant in the real number version, **not dB**.

Finally, we multiply this by the IF bandwidth of the receiver to be used. The IF bandwidths of receivers are between 22 and 36 megahertz and are typically 30 megahertz. The formula is written as follows:

$$\text{CNR} = [A - \leftrightarrows - G] - 10\log[(T1 + T2) \times B \times N]$$

Where A = Bird EIRP in dBw
⇆ = Path Loss in dB
G = Antenna Gain in dBi
T1 = Antenna Temp. in °K
T2 = LNA Temp. in °K
B = Boltzman's Constant in real numbers
N = IF bandwidth of receiver

Let us try an example and assign values for each term used in the calculation of CNR. We will use Montreal, Canada for our location and Satcom 1 as the satellite. Let us assume we are receiving with a 12 foot shrouded dish and a 120° LNA. You may wonder why we don't add the gain of the LNA to our formula since we are adding the noise level. The reason is that the LNA will amplify the (antenna received) noise as well as the signal. Thus, if we add 50 dB to the signal we must also add 50 dB to the noise and since we are subtracting the noise from the gain of the signal the two would cancel each other out. However, since we must use the LNA to raise the **power** of the signal so that the receiver can have the proper input level, we must add the **internal** noise of the LNA to the CNR calculation.

Using the nomenclature of 2-a and the test case values as used in the first case we have:

$$\begin{aligned}\text{Constant} &= (\text{Path loss in dB} - \text{IF bandwidth in dB}) \\ &\quad - (\text{Boltzman's Constant in dB}) \\ &= [197.4 - 10\log(30\times10^{6})] - [10\log(1.381\times10^{6})] \\ &= [197.4 - 74.8] - [228.6] \\ &= -43.6\end{aligned}$$

(Formula 2-d)

(Formula 2-a)

A	= Bird EIRP	= Satcom 1 at Montreal	= 33.5 dBw
C	= Path Loss	= Satcom 1 to Montreal at 3.95 GHz	= 197.4 dB
G	= Antenna Gain	= 12 foot dish loaded to the point where the edges are 10 dB down.	= 41 dBi
T1	= Antenna Temp. in °K	= Same as above at 11° look-angle	= 50°K
T2	= LNA Temp. in °K	= Common LNA with 120° spec & 50 dB gain	= 120°K
B	= Boltzman's Constant		= 1.381×10^{-23}
N	= IF bandwidth	= Standard 30 MHz IF	= 30×10^{6}

$$\begin{aligned}\text{CNR} &= [A - C + G] - 10\log[(T1 + T2) \times B \times N] \\ &= [33.5 - 197.4 + 41.0] - 10\log[(50 + 120)\times 1.381\times10^{-23} \times 30 \times 10^{6}] \\ &= [33.5 - 197.4 + 14.0] - 10\log[170\times1.381\times10^{-23}\times30\times10^{6}] \\ &= [-122.9] - 10\log[7.04^{-14}] \\ &= [-122.9] - [-131.52] \\ &= 8.62\end{aligned}$$

This formula might be a 'little' long for those wishing to quickly calculate a CNR for changing circumstances. Let us assume that for our CNR calculations that the location, Boltzman's constant, and the IF bandwidth will remain the same. For this we need a formula to calculate the CNR where all these factors are represented by a constant.

The following is such a formula.

$$\frac{\text{ANT. GAIN}}{10\log(\text{Noise})} + \text{EIRP} + \text{Constant} = \text{CNR}$$

ANTENNA GAIN

The term 10 log (Noise) represents the "Figure of Merit" or G/T°, a term commonly used in microwave. The Figure of Merit is handy for assessing an antenna and amplifier combination. Using the same example as we did for the long CNR formula, we will calculate an actual G/T°.

$$\begin{aligned}G/T^\circ &= \frac{G}{10\log(T1 + T2)} \\ &= \frac{41.0}{10\log(50 + 120)} \\ &= \frac{41.0}{10\log(170)} \\ &= \frac{41.0}{22.3} \\ &= 18.7\end{aligned}$$

This formula uses the same nomenclature as formula 2-a. To complete the formula (2-b) we must have the constant.

This constant can be altered to suit any location and IF bandwidth by substituting the appropriate values in formula 2-d. Therefore, we can go back to formula 2-b and use our constant and **Figure of Merit** and see how the short formula compares to the long one.

(Formula 2-b)

$$\begin{aligned}\text{CNR} &= G/T^\circ + \text{EIRP} + \text{CONSTANT} \\ &= G/T^\circ + A + C \\ &= 18.7 + 33.5 + (-43.6) \\ &= 8.6\end{aligned}$$

What does the CNR mean? Knowing it means that we can make a good guess as to what your picture will be like. Most TVRO satellite receivers get their specs for picture quality from a **given CNR** at the input of their receivers. Receivers can and will vary slightly as to the picture quality delivered by a certain CNR due to design and difference in noise temperature of the internal components. If you have already decided on a receiver then by all means use the advertised CNR requirements of the receiver you are going to use. The list below will give you the type of picture you can expect from the average receiver.

CNR	PICTURE QUALITY
below 6	Poor quality picture, loss of detail, no color or with very poor color, lots of noise with sparklies and all the other defects very weak signals exhibit.
6 to 8	Marginal reception, some loss of detail, color can be poor, noise level is usually apparent, sparklies can be annoying to watch.
8 to 10	Good reception, good detail, good color, slight noise evident mainly on heavily modulated color bar patterns, many will feel the picture quality is excellent.
above 10	Very good reception, sharp picture, excellent color, no noise or slight noise only on color bars, picture is usually better than the picture delivered by cable on their best channels.

We can see by our test example, a 12 foot dish with shroud in Montreal employing a 120° LNA, that the system is about the minimal that could be used to watch RCA Satcom 1. Our conditions, however, are about the toughest in North America except perhaps for those of the Far North, Florida, and East

Coast regions above New York where very large antennas are the only hope for good reception.

Table 2-a provides calculations of CNR levels for different LNA and antenna combinations.

CNR Levels for 10' and 12' Parabolic Dishes

	10 Foot Dish			**12 Foot Dish**		
LNA (Degrees K)	150°	120°	100°	150°	120°	100°
Figure of Merit	16.9	17.7	18.4	18.5	19.4	20.0
Satellite EIRP		CNR			CNR	
36	9.3	10.1	10.8	10.9	11.8	12.4
35	8.3	9.1	9.8	9.9	10.8	11.4
34	7.3	8.1	8.8	8.9	9.8	10.4
33	6.3	7.1	7.8	7.9	8.8	9.4
32	5.3	6.1	6.8	6.9	7.8	8.4
31	4.3	5.1	5.8	5.9	6.8	7.4

For the purpose of the chart we are assuming the following:

- the distance from site to satellite is 26,500 miles.
- the IF bandwidth is 30 MHz.
- the look angle is 40°.
- the frequency of reception is 3.95 GHz.
- the 'loading' of the dish is at the point where the edge is 10 dB down from the middle.

For a fast, direct method of comparing any change that you might make in the LNA and antenna combination, use the Figure of Merit. A 1 dB improvement in the Figure of Merit will give a 1 dB improvement in the CNR, a 2 dB improvement yields a 2 dB improvement in the CNR and so on.

The question of shrouding the dish is also best answered by comparing the improvement that you are likely to get in the Figure of Merit by the addition of a shroud. A shroud **may** be worth while when there is local microwave interference or if the look-angle of the dish is very low, 12° or under. For example, if we can reduce the temperature of the antenna by 30°K with the addition of a shroud, without a shroud we presume the antenna temperature to be 90° and with the shroud the temperature would be 60°. For a 120° LNA and a twelve foot dish we can calculate the Figure of Merit with and without the shroud.

With Shroud:	Without Shroud:
$\frac{41.0}{10 \log (120 + 90)}$	$\frac{41.0}{10 \log (120 + 60)}$
17.8	18.4

Therefore, the CNR would be improved by the difference in the Figure of Merit, which in the above case is .6, and you would make your decision as to whether a shroud would be worth the effort.

Occasionally in the TVRO world the term S/N ratio pops up. This is a specialized S/N ratio used by TV studios, cable TV companies and the like to describe the signal quality as it affects the TV receiver. The TV S/N ratio has the FM advantage of the satellite TV receiver built into the formula. Typically, adding about 37 dB to the C/N ratio (when C/N **plus** 37 equal 48 **or more**) will produce the TV S/N ratio. The CNR is a much easier value to understand, which is why we are using it instead of the TV S/N ratio.

HOW TO BUILD YOUR FORM

To build a parabolic dish you first must have a parabolic dish form. Since parabolic dish accuracy depends largely on the accuracy of the form, the success of the project depends on the form's careful construction. Most of the effort and about 40% of the cost of materials for building the dish are concentrated in fabricating the form.

The mold itself is light and strong, easy to work with, and breaks down into a small package for shipping or storage. It is the easiest way of forming a dish that is on the market to date. All materials in the form are easily obtained and the mold can be assembled with hand tools. An electric sabre saw is helpful to cut out the curved part of the form.

It is impractical to build a form, use it once, and then discard it or store it away in the basement to gather dust. Your work should be rewarded by your having the option to sell or rent the form you constructed. Along with this manual you will find a page on which your comments on the manual and your success with the project are requested. **If you have a mold to sell or rent simply indicate this at the appropriate place on the comment sheet.** This information will be stored and distributed to those who request information on finding a pre-built form. This offer to list your form for rent or sale is conditional on your purchase of the manual. No offers for sale or rental of forms will be accepted that are not made on this comment sheet from this manual. If you want to go into the business of renting forms, fine - but each form offered through the author for rental must include the purchase of a manual.

In order to facilitate your project the author has contracted a Canadian firm to build forms. These forms differ from the one described in this manual only in that they are bolt-together units and many of the pieces are made of metal for greater accuracy and ease of assembly. These forms will be made available to those wishing to rent a form (see the list of suppliers at the end of the manual). This supplier will also sell any part of the form that you have difficulty in acquiring.

As a service to those who have purchased this manual, a list of the people who have forms for sale or rent will be supplied for the fee of $5.00 (postage and handling). In order to receive this information list you must send the coupon enclosed with the manual. No request will be considered that is not accompanied by this coupon (page 32).

If you have decided to build the form it is time to order your materials and prepare a 15' by 15' space in which to work. The first step is to lay out the parabolic form onto a piece of ¼" plywood, good both sides. Using **Table B** from Chapter I we will lay out several points onto the plywood, **leaving a 12" margin** along the bottom of the piece of plywood (**illustration III-a**). You **can** assume that the edges of a piece of plywood are straight, but you might want to **check** the squareness of any corner you intend to use as a square point. The 12" addition to the template allows the form to be laid out right on the template to facilitate accurate set up.

The next step is to mark a 12" line parallel to one of the long edges. Refer to illustration 3-a, line "a". Next, mark a 12" line from the other edge of the plywood, line "b". The spot where x = 0 and y = 0 is point "c" on illustration III-a. The points where y has a value of 54" and x has a value of 13.5" can be found by measuring 54" from left-to-right on line "a" and then moving perpendicularly down from line "a" 13.5".

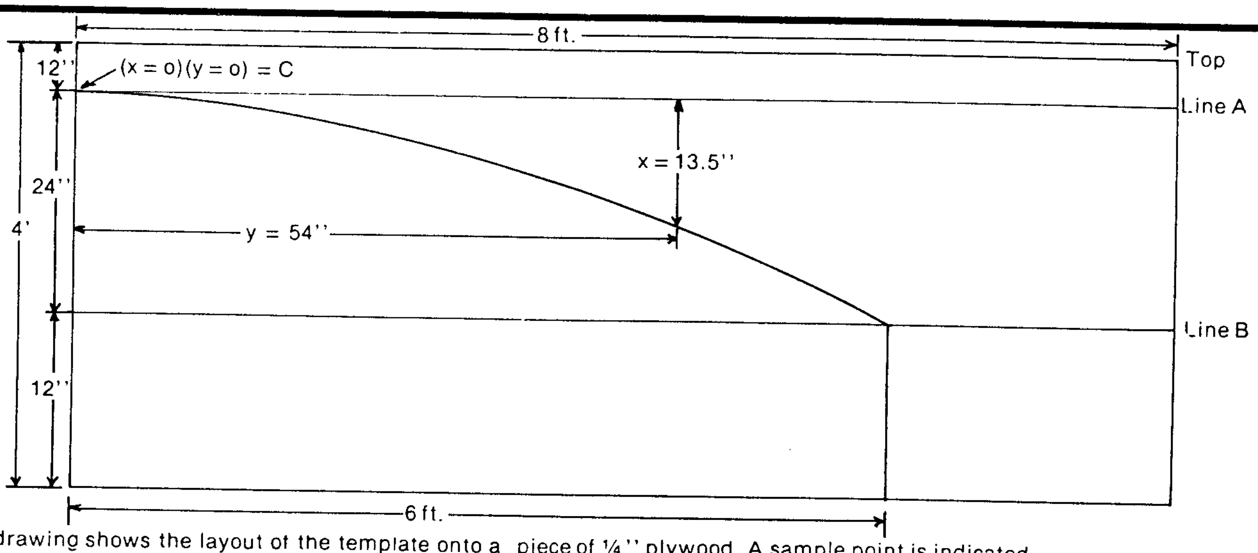
Lay out on the plywood the points where y moves in **6" increments** and mark them lightly with a pencil. This will give the rough shape of the parabolic curve to be laid out. Start laying out graph paper (the type with 1 inch heavy lines subdivided into 100 small squares, commonly called 1 inch 10 x 10) **along the curve** with reference to the line "a". Check carefully against the side edge of the plywood so that the grid pattern is on the plywood as accurately as possible.

Using a sharp pencil, lay out all the points from Table B onto the graph paper, moving in .5" increments. After all the points are marked onto the graph paper, check that they all follow a smooth curve. Re-check and re-plot any one that seems to fall out of the curve. Using a sharp object, the point of a compass or a metal scribe, poke through each point on the graph paper so that small holes are made in the wood. Remove the graph paper. With the aid of a French curve or by freehand **trace a line joining all the punctures**. Use a sharp pencil and try to keep the line as thin as possible.

Now, cut out the template with a sabre saw. **Make the cut leaving enough space on top of the line that the line always remains intact.** The edge can be sanded down **after** but it is difficult to compensate for cutting too closely.

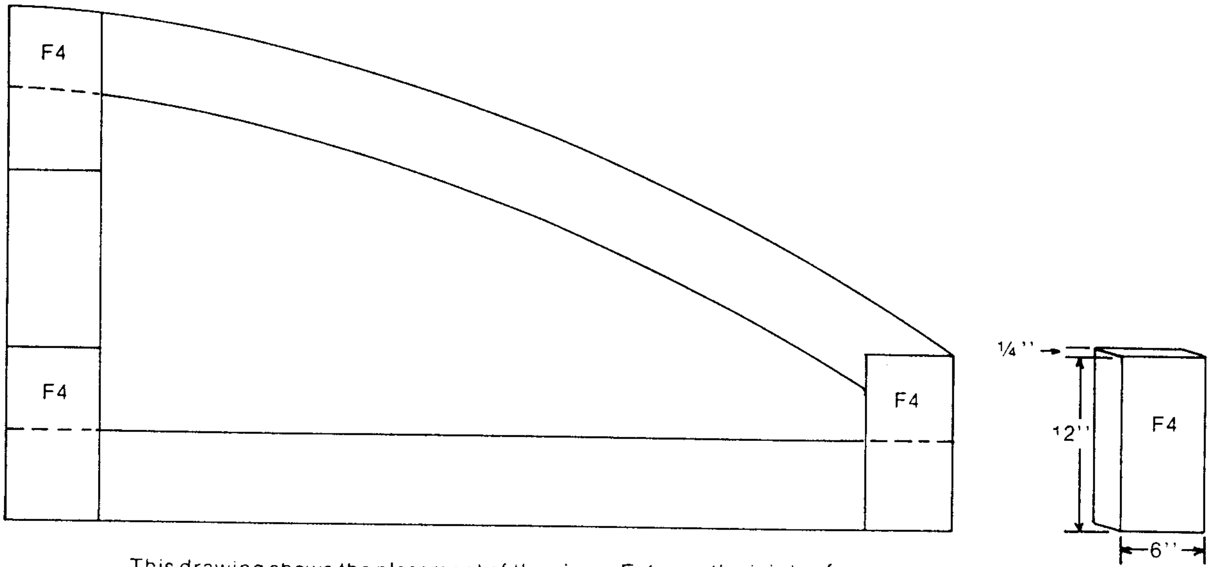
The template must now be drilled to make the points where the leaves will be drilled to accomodate the fiberglass rods. Measuring from the 36" straight edge of the template, mark a point 17-3/8" from that edge which is 3/16" away from the curved surface (the 17-3/8" is measured parallel to the straight bottom edge of the template). Continue, and measure the points 28-1/8", 37-3/8", 46-5/16", 56" and 64-11/16" in the same manner as you did the 17-3/8" point (**illustration III-c**). Drill holes at these points with a 1/4" drill. The 1/4" holes will allow the leaf portion to be marked without endangering the edge of the template. **There should be 1/16" of wood left between the hole and the curved edges of the leaves.**

Using your template, cut out pieces "F-1" as shown on **illustration III-d**. These are the curved portions of the leaves.



This drawing shows the layout of the template onto a piece of ¼" plywood. A sample point is indicated where (y = 54") and (x = 13.5").

Illustration III-a



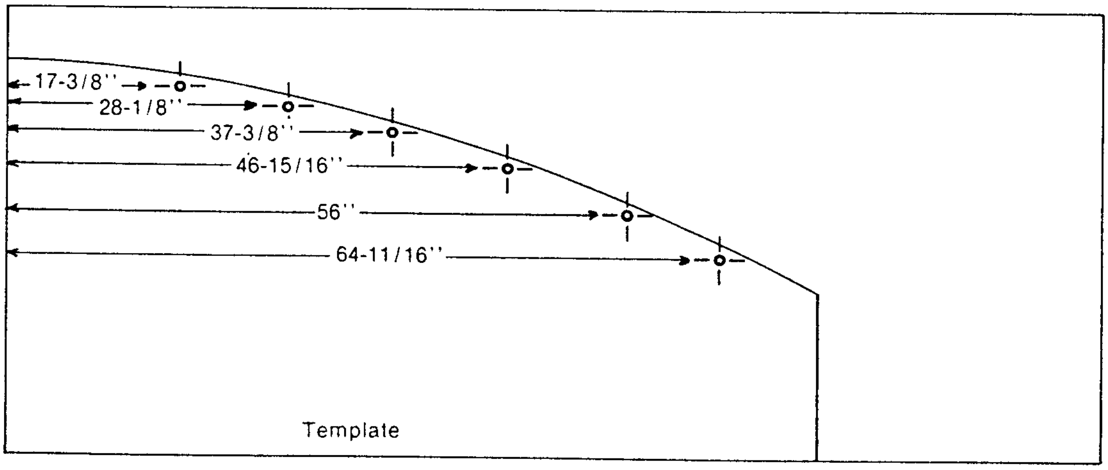
This drawing shows the placement of the pieces F-4 over the joints of the leaf.

Illustration III-b

The easy way to do this is to lay them out on the plywood so that the top of one piece forms the bottom of the piece above it. The accuracy of the bottom of each piece is not critical so careful cutting of the **top** edge will make an adequate bottom edge for the other. Again, it is good practice to cut slightly **above** the line so that the edge can be sanded **down to the line**. It should be noted that the F-1 pieces are cut so that the front edge (where F-3 sits) is 1-3/4'' back from the edge. Six of these pieces are needed, cut from 3/4'' good-both-sides plywood.

Cut pieces F-2 and F-3 from the same 3/4'' good-both-sides plywood. A table saw would be handy but a sabre or hand saw will suffice. **Six** pieces **of each** are required. Cut the pieces F-4 out of 1/4'' plywood, good-one-side. **Thirty-six** pieces of F-4 are required.

The easiest way to assemble the leaves accurately is to lay out the pieces F-1, F-2, and F-3 on top of the template (**illustration III-d**). Mark off 1-3/4'' on the template so that pieces F-1 and F-3 can be lined up accurately on the line. Lay out pieces F-1, F-2, F-3 on top of the template and clamp in place. Drill holes along the edge of F-1 by passing a 1/4'' drill through from the template side. Take three pieces of F-4 and spread glue on one side. Place them over the joints of F-1, F-2 and F-3 and countersink four holes so that they can be attached with 3/4'' #8 wood screws (countersink type). See **illustration III-b** for placement of the F-4 pieces. After the screws have been tightened in place, remove the clamps holding the leaf pieces to the template and lift the leaf away from the template. Be sure to do this **before** the glue dries so that you don't accidentally stick the leaf to the template. Turn the partially assembled leaf over and place three more of the F-4 pieces over the joints as was done on the other side. Glue and screw in place. Enlarge the 1/4'' holes that were drilled when the piece F-1 was on the template to 3/8''. **The 3/8'' holes** should come right to the **edge** of the curved section of F-1. In fact, when inserted, a portion of the fiberglass rod will be visible along the **top** of the hole. Set the leaves aside to dry overnight.



This drawing indicates the spots where the holes are drilled through the template to assist in laying out the holes in the F-3 pieces.

Illustration III-c

This drawing shows the pieces F-1, F-2, and F-3 in place over the template. The only portions of the template that can be seen are the 1¾'' on the left hand side and the middle of the template on which the F pieces border.

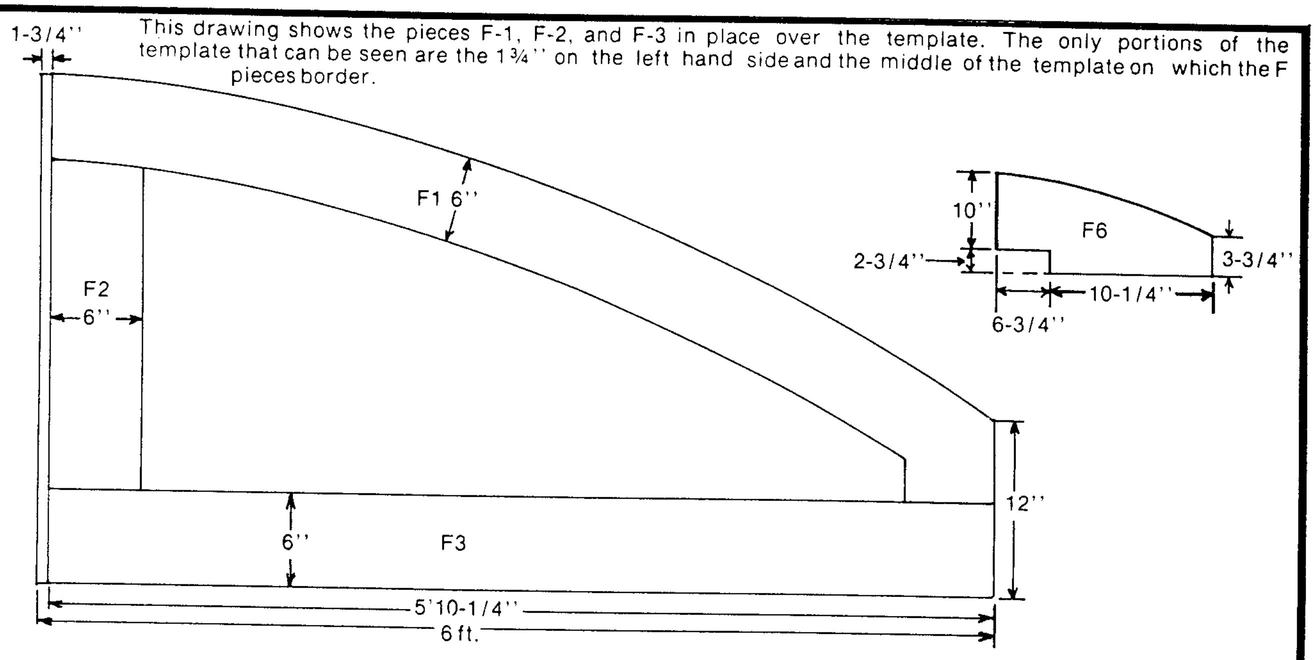
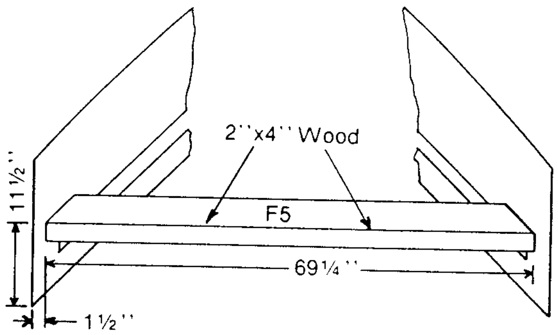


Illustration III-d



This drawing shows the piece F-5 which is a pine 2''x4''. The placement of the piece F-5 into the leaves is accomplished so that the top of the 2''x4'' is 22½'' from the bottom of the leaf and 1½'' in from the edge of the leaf.

Illustration III-e

Cut a 2 x 4 so that the outside edge of the 2 x 4 is 69-1/4'' long. The cut should be **30° from perpendicular** so that the 4'' face is tapered to a smaller size than 69-1/4''. No accurate inside measurement is given because 2 x 4s tend to vary in width. **Six** of these 2 x 4s are required (**illustration III-d**).

The hub is one of the parts that is difficult to build from wood because it is a round center section. The commercial hub has a steel hub. Luckily, modern plumbing supplies us with exactly what we need for the other parts of the hub: A.B.S. pipe and toilet flanges. Presumably US toilet flanges are identical to Canadian ones. Two different Canadian types have the same outside diameter of 7'' and an identical 6 hole bolt pattern. If the flange you buy differs in outside diameter you will have to change the diameter of the plywood disc to match it. If the bolt pattern differs from the 6 hole pattern, you will have to redrill the flange piece to conform to the 6 hole pattern (see suppliers list at the end of the manual for sources for these).

Cut a 33'' piece of 3'' A.B.S. plastic drainpipe (outside diameter). **Fit** the flange pieces over the ends of the drainpipe: do **not** glue. Place the pieces so that the total length of the hub is 35-3/4''. Mark the drainpipe by scoring the circumference where the flange ends. Then mark the flange and drainpipe so that the screw holes will line up when the pieces are glued together. Disassemble the plastic drainpipe and flanges and spread glue onto the **inside** of one of the flanges. Then reinsert the pipe into the flange lining up all your marks. **Work quickly** as the glue tends to harden **within 30 seconds**. Repeat the process for the other flange, again making sure all the marks line up (**illustration III-f**).

Next make a wooden disc 7'' in diameter from 1/4'' plywood. Drill 6 holes in the disc to line up with the holes in the toilet flange. Countersink the holes in the plywood disc with a countersink tool.

After the hub has been assembled the leaves will have to be notched to accomodate the flange part of the hub and the plywood disc. The plywood disc is placed at the top of the form where the curved part of the leaves fit the hub. **The groove you will cut** into the leaf will be **larger at the top than at the bottom**. This groove is not too critical but must allow the hub to fit so that the edges of the leaves come in contact with the drainpipe (**illustration III-f**).

Collect all the leaves, the hub and the F-5 pieces and start the assembly. Have some bricks and plywood scraps handy for leveling the pieces during assembly. Start off by assembling the hub and one of the leaves so that the leaf is centered between the screw holes of the flanges. When the pieces are properly lined up **drill a small pilot hole** into the edge of the leaf. It is **important** to drill the pilot holes because the plywood will **split** when the screw is installed if no hole has been drilled. Screw the hub to the leaf making sure to include the plywood disc at the top. After both sides of the hub have been attached to the leaf, repeat the procedure by installing the leaf from the one you just installed. **Stand the hub up** with the plywood disc at the top and level by shimming under the hub and outside edges of the leaves where necessary. Next, add all the remaining leaves by attaching with screws at the top only. It is a good idea at this point to wrap all the bottoms of the leaves together with black plastic tape. Use a liberal amount of tape, 50 wraps or an entire roll. Make sure that the bottoms of the leaves make contact with the drainpipe when you wrap the leaves with the tape. It is a good idea to shim all the leaves at this point.

Install the pieces of 2'' x 4'' F-5 so that they are 11-1/2 inches from the bottoms of the leaves to the top of the 2'' x 4'' and 1-1/2'' in from the ends of the leaves. The best method is to put the end in place and countersink a hole for 2-1/2'' #8 screw and screw in place with two screws per end. If by the time you get to the end the last 2 x 4 does **not fit** or if it slides too far into the form, you may have to move the prior-attached 2'' x 4'' pieces **out or in** to make fit.

Piece F-6 attached to piece F-5. Piece F-5 in the photo is made of steel which is the material used in the rental form. F-5 as described in the manual is made of wood.

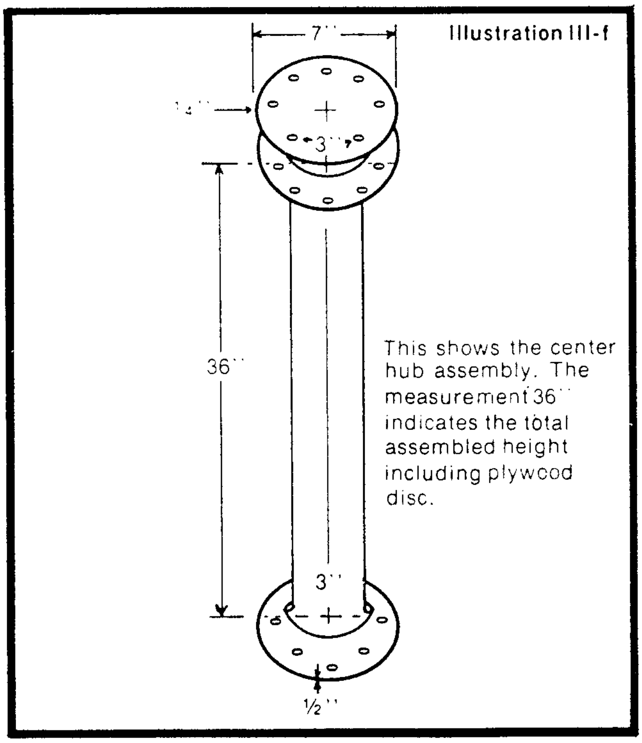


Illustration III-f

This shows the center hub assembly. The measurement 36'' indicates the total assembled height including plywood disc.

When all 2'' x 4'' pieces have been installed it is time to solicit help from the neighbors to lift the form up so that the remaining screws can be inserted through the hub and leaves. Be careful to lift it **only by the leaves** which have their bottom parts screws in. It may be handy to support it off of the ground by setting it on two chairs while performing this function. Lower the form back down and check the level again, shimming where necessary.

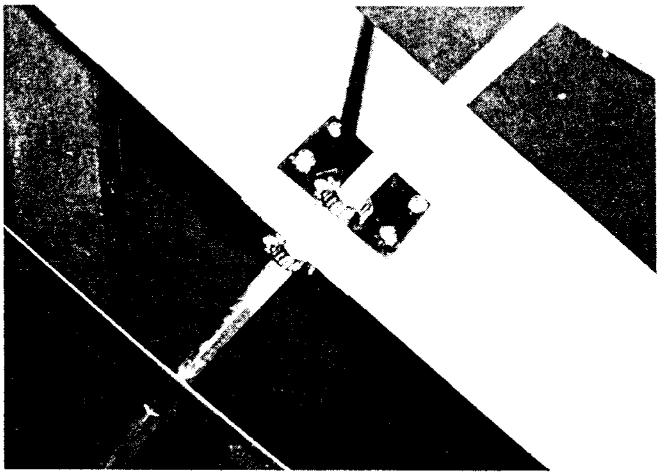
The next step is to mount the fiberglass rods into the form. First of all, refer to **Table III-A** in which the fiberglass rod lengths needed for each hoop are given under "Circumference." We found that the local fiberglass supply shop sold the rods in 20 foot lengths which were awkward to transport. Cutting them in half and calculating the number of 10 ft. rods required for each makes it easier.

You will need hard copper coupling tubes with ID of 3/8 inches of the 3/8'' rod and of 1/2'' ID for the 1/2'' rod. This copper tubing is available from a plumbing supply. Be sure **not** to get the **soft type** of tubing as it will not hold the formed shape. The tubing has to be bent **before** cutting. Do this by bending the tubing over something round such as a paint can. The smaller hoops require a tighter bend on the coupling pieces than do the larger ones. When you feel you have the proper bend on the coupling tubes, cut them out so that they are **5'' in length**. With a **wide** felt tipped pen mark 2-1/2'' off on each fiberflass rod end that you have cut to make the desired length of fiberglass hoop. This will allow you to **monitor** the amount of fiberglass rod you are putting into each coupling tube. Pre-assemble each hoop on the ground so that the roundness of each hoop can be checked before final assembly. Note any flat or peaked places that occur in the hoop at the coupling tubes and straighten or increase the bend of each coupling piece until the hoop appears round to the eye.

When you are satisfied as to the roundness of each hoop pull the hoop apart and carry it to the dish, feed the rods through the leaves and join them together with the coupling pieces. Do this for rings two through five(six).

Ring 1 should be left assembled for installation. This is accomplished by making the holes into **slots** where ring 1 fits into the leaves and can be placed directly into them from the top. The hoop can be held in place by the use of the drilled plates (see photo), rubber cement or a compound like "GE Sealer."

The next steps are separate. Follow the first step if you are building a **10** foot dish, or the next if you are building the **12** foot dish.



Fiberglass rod passing through one of the leaves. Note the leaf has been reinforced with a steel plate where the fiberglass rod passes through it [optional]. Also not the hose clamps stop the rod from sliding back and forth in the leaf.

If you are building the 10 foot dish you can now mount the 1/2'' diameter fiberglass rod hoop which will be the perimeter of the dish. It is affixed to the forms by 6-1/2 hose clamps screwed into the wooden leave. Make the attaching screws accessible by turning the hose clamps **backwards**. Have the mounting screw towards the perimeter of the form. The hoop will sit **on top of** the leaves, unlike the other hoops which sit under the surface of the leaves. This hoop will remain a part of the dish and will be removed from the form when the dish is complete.

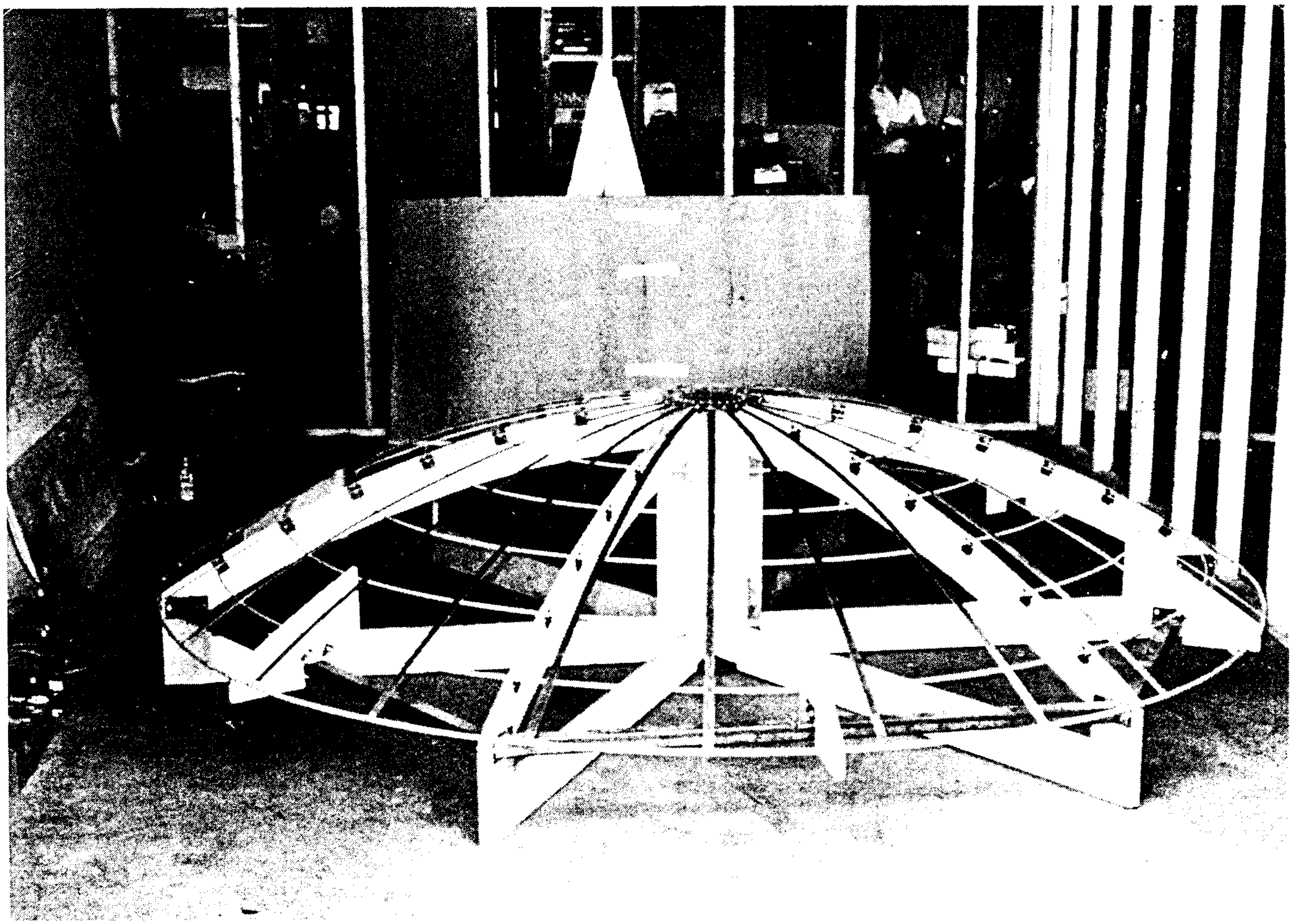
If you are building the twelve foot dish you must add

TABLE III-A

	Ring Radius in inches	Converted To Decimal	Diameter	Circum-ference	10' Piece of rod
Ring #1	17-3/8	17.38	34.76	109.20	1 of 3/8''
Ring #2	28-1/8	28.13	56.26	176.75	2 of 3/8''
Ring #3	37-3/8	37.38	74.76	234.87	2 of 3/8''
Ring #4	46-15/16	46.94	93.88	294.93	3 of 3/8''
Ring #5	56	56.00	112.00	351.86	4 of 3/8''
10' dish ½''diameter perimeter rod	60-1/8	60.13	120.26	377.61	4 of 1/2''
Ring #6	63-11/16	64.69	129.38	406.46	4 of 3/8''
12' dish ½''.diameter perimeter rod	72-1/8''	72.13	144.25	453.96	4 of 1/2''

Rods required for a 10 foot dish: 11 (10 ft. length) 3/8'' diameter
4 (10 ft. length) 1/2'' diameter

Rods required for a 12 foot dish: 15 (10 ft. length) 3/8'' diameter
4 (10 ft. length) 1/2'' diameter



The form assembled. Note the center hub and joiner strips. The first two steps in Chapter IV have already been accomplished.

pieces F-6 to help support the outside rings. Make a second template by placing a piece of cardboard of the original template and drawing the curve for the final 20 inches of the leaf. With reference to the back edge of the template add the dimensions from **illustration III-a** and cut out as accurately as possible. It is also advisable to mark the template with the last two fiberglass rod holes (the ones for rings 5 & 6). With the template make six F-6 pieces from 3/4" plywood.

Measure half-way across piece F-5 and mount a 5 inch piece of angle iron with two holes drilled into the piece sticking up. Of course, you will need two holes in the bottom of the angle iron so that it can be screwed down to the 2 x 4. Hold the F-6 piece in place so that the holes line up with ring #5 and mark the spot where the piece must be drilled so it can be bolted to the piece of angle iron mounted on F-5. Drill the marked holes to 3/4" in diameter. This will allow piece F-6 to be adjusted to line up properly.

Loosely mount the F-6 pieces by placing a 3/8" bolt 1-1/2" in length through the angle iron. Place the piece of F-6 through the bolt. Then place a 3/8" ID flat washer over the first washer and then the 3/8" nut. Do **not** tighten so much that the piece F-6 cannot be moved. Install ring #6 through all the pieces of F-6 and the leaves.

The next step is applicable for all dishes.

The fiberglass rings must be aligned accurately. To accomplish this place a string at the center of the wooden disc at the top of the form. A string tied to a washer and fastened with a screw nail will do nicely. Check each mounting hole in the wooden leaves as well as the mounting holes in the pieces F-6 for accuracy to the circumference. If any hole is more than 1/8" out of place, correct the error. Check the hoop between the leaves for bulging and hollowness. Adjust the fiberglass rod by pushing or pulling on the section you are checking until it is perfectly rounded. When you have a section aligned place hose clamps or "GE Sealer" on the fiberglass rod **to keep the rod from slipping** through the leaves. Continue this procedure for each section. If this cannot be accomplished because the hoop is too small or too large, adjust the circumference until accuracy can be achieved. **Do not compromise at this point** because the accuracy of the project and your overall success depend on the form being set up properly.

Additionally for the 12 foot dish, after rings 5 and 6 have been aligned, tighten the bolts holding the F-6 pieces. Finally, install the 1/2" diameter fiberglass rod which forms the outside perimeter hoop and mount it onto the form by the use of 12-1/2" aluminum hose clips. The length of the rods needed is found in **Table III-A**. The hose clips are attached by 3/4" #8 wood screws screwed into the flat back edge of the leaves and the pieces F-6. Be sure to mount the fiberglass perimeter hoop so that it sits up **above the level** of the projected surface of the dish as this fiberglass hoop will remain part of the dish and the aluminum petals will wrap around it (photo).

MATERIALS LIST FORM REQUIREMENTS

Graph Paper	•20 sheets 8½x11, 10x10 grid, 1" squares.
Fiberglass Rods	•10 ft. dish - 11 pcs., 10 ft.x3/8" diam. 4 pcs., 10 ft.x1/2" diam. •12 ft. dish - 15 pcs., 10 ft. x 3/8" diam. 4 pcs., 10 ft. x 1/2" diam.
Copper Tubing (Hard)	•1 pc. 10 ft. x 3/8 ID •1 pc. 4 ft. x 1/2 ID
Wood	•2 pcs. ¼" plywood (good both sides) 4'x8' •2 pcs. ¾" plywood (good both sides) 4'x8' •6 pcs. 2" x 4" pine 8 ft. length.
A B S Plumbing Supplies	•2 pcs. 3" Floor plate (4"x3" with 6 mounting holes) •33" 3" ID drainpipe (schedule 40) (3½" OD) •1 pint ABS glue.
Hardware	•12 pcs. 1½"x3/8" coarse bolts and nuts. •100 #8x3/4" Countersink wood screws. •50 #8x2½" Countersink wood screws. •12 Flat washers (large OD) 5/8" bolt size. •12 Flat washers (large OD) 3/8" bolt size.
Miscellaneous	•16 oz. white glue (Elmer's) •12 pcs. ½" hose clips (see ill. IV-h) alum. •10 ft. dish - 48 ½" hose clamps •12 ft. dish - 72 ½" hose clamps •1 roll black plastic (electrical) tape.

FORM NOTES

CONSTRUCTION OF THE PARABOLIC DISH

The final design and construction technique of the dish involves several special considerations. The materials needed should be readily available, economical and easy to work with, requiring no specialized tools. The dish constructed from these materials must be strong, rigid and fully functional. It must also be lightweight and easy to mount. **Combining a solid aluminum skin** for the reflective surface with 12 reinforcing ribs and a fiberglass backing fulfills all of these requirements. With careful assembly and attention to detail you will end up with a product that will look and perform as well as the commercially available units.

CONSTRUCTION OF THE 12 FOOT DISH

The first part required in the assembly of the dish is the hub center, a 12-5/8" diameter disc cut from a sheet of aluminum (the same material used for the petals) starting with a square sheet of aluminum (13" x 13", approximately). Find the center and drill a 1/8" hole through it. This hole will be used later for screwing the hub center to the form. Now, using the center hole as a pivot point, mark the 12-5/8" circle with a piece of string and a pencil and scribe. Then carefully cut out the disc with tin snips or shears (**illustration IV-a**).

Now that you have the hub center cut out, the next step is to drill the holes which will be used to secure the 24 aluminum joiner strips to the hub. There are two sets of 1/8" holes. **The first set** is 1/2" from the perimeter of the hub, spaced equidistantly around it. **The second set** is 3" from the

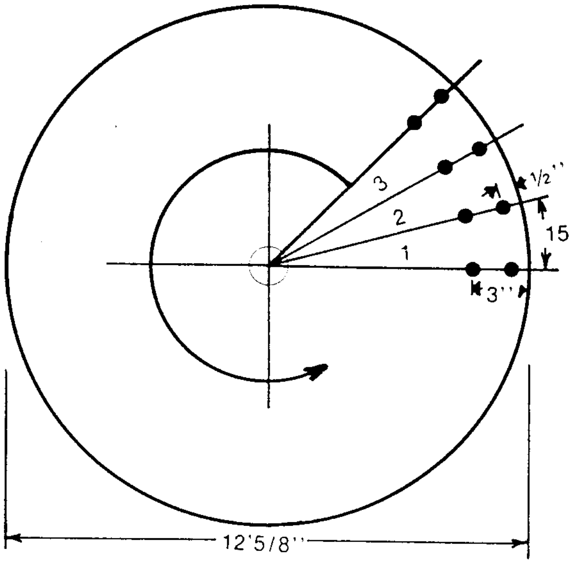
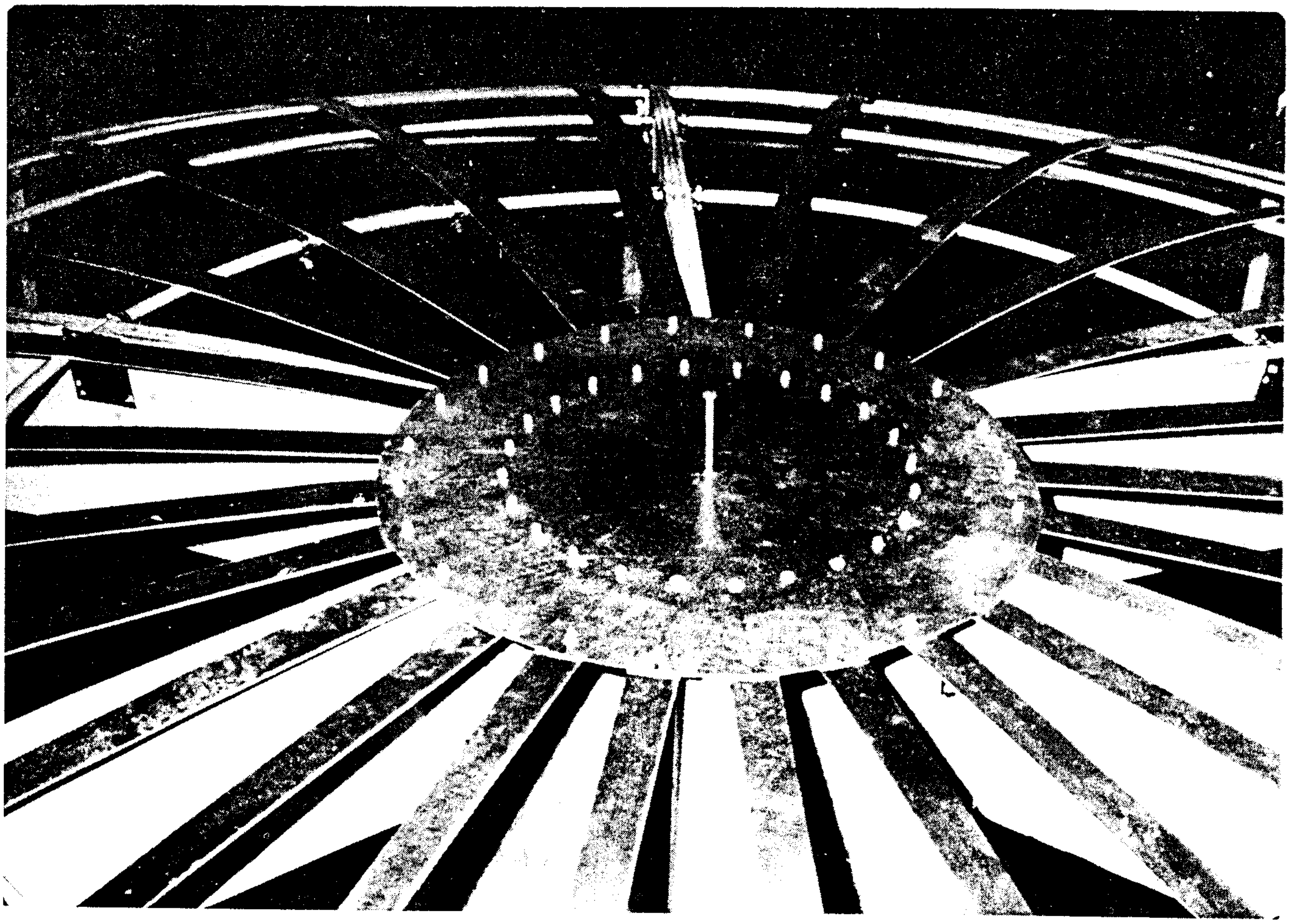
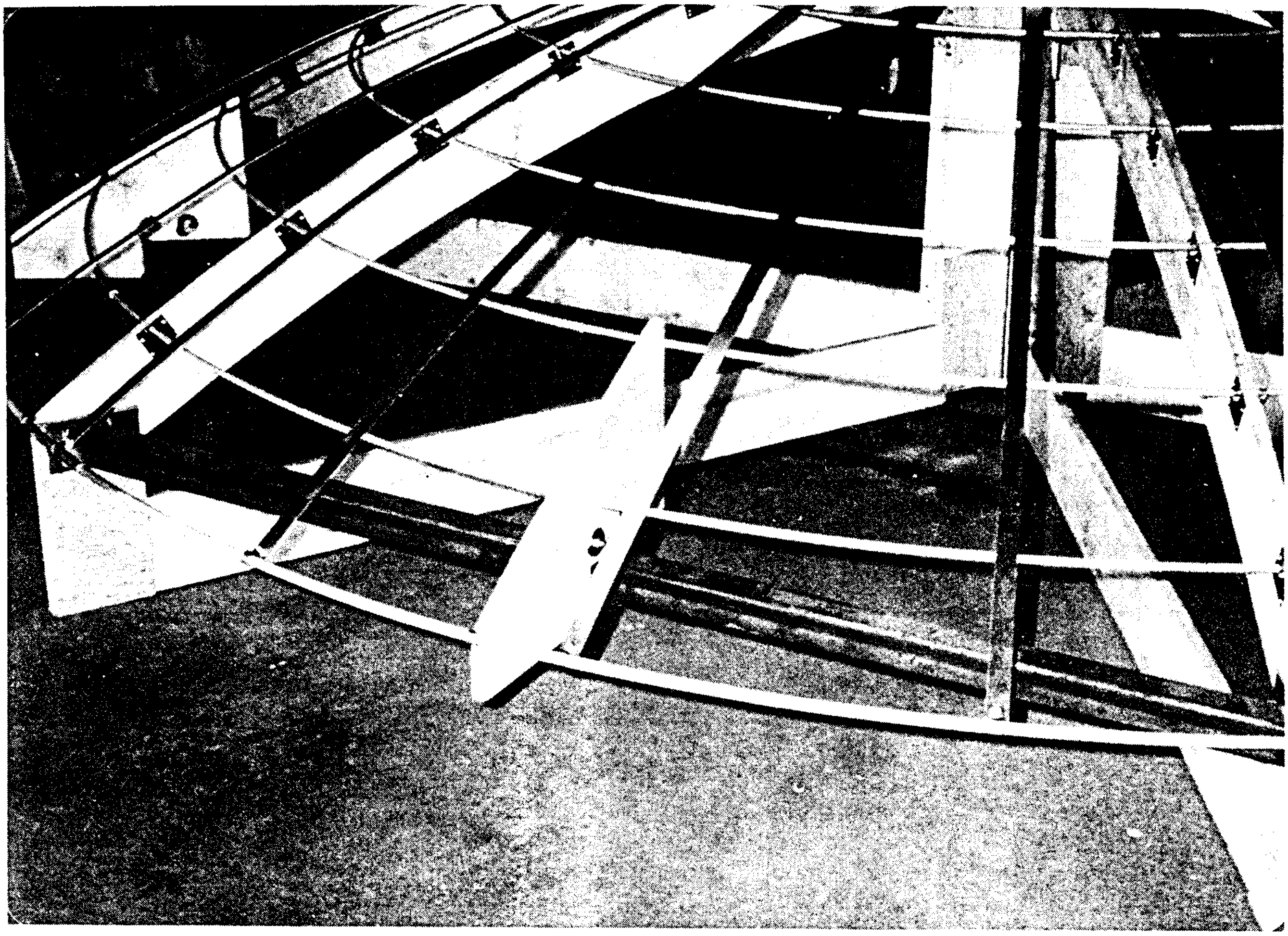


Illustration IV-A


Hub center and lower joiner strip assembled on form.



24 lower joiner strips mounted to perimeter rod.

perimeter, also spaced equidistantly. There are 48 holes in all - two on each radial.

Now that the hub center is ready, cut 24 strips of the 1" x 1/16" aluminum to a length of about 70" each. At one end of each strip drill two 1/8" holes. The first hole should be 1/2" from the end and the second 3" from the end (**illustration IV-b**).

Take a predrilled joiner strip and with the hub center on top, align the two holes with two of the radial holes in the hub center. Pop rivet them together. Attach all 24 joiner strips in this manner (see photo). Now carefully lift the whole assembly into position on the form and using the centering hole, bolt the hub onto the form. **Be careful** not to bend or twist the aluminum strips!

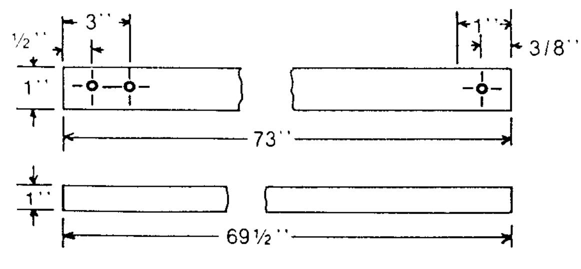


Illustration IV-b

To secure the aluminum strips to the outer perimeter of the dish, mark off 24 equidistant points on the outer rod (see photo). Try to arrange the points so that the joiner strips run on **either side of** the coupling tubes of the fiberglass rods. Then install the clamps at each of the 24 marks on the perimeter rods (see photo).

Pulling the lower joiner strips so that contact is maintained on all the fiberglass rods without bending them, mark and drill a 1/4" hole in the end of the joiner strip so that the clamp will line up and maintain the tension of the joiner strips when they are bolted to the perimeter rod. If necessary, elongate the holes with the drill to obtain extra adjustment. **Do all 24 lower joiner strips in this manner** and check they are spaced equidistantly around the perimeter. Apply double sided tape to the top side of each joiner strip, leaving the protective covering on the exposed side (**illustration IV-f**).

We are now ready to cut out the petals. To obtain maximum uniformity, cut a **master** template from 1/4 inch plywood using table IV-A. Using the master template, trace the pattern onto the aluminum sheets. With careful arranging you can get 4 petals from each 4' x 8' sheet. For marking lay the sheets on a smooth clean surface, such as plywood, to prevent dimples or wrinkles. Carefully cut out the 24 petals, being wary of the sharp edges; you should wear gloves if possible.

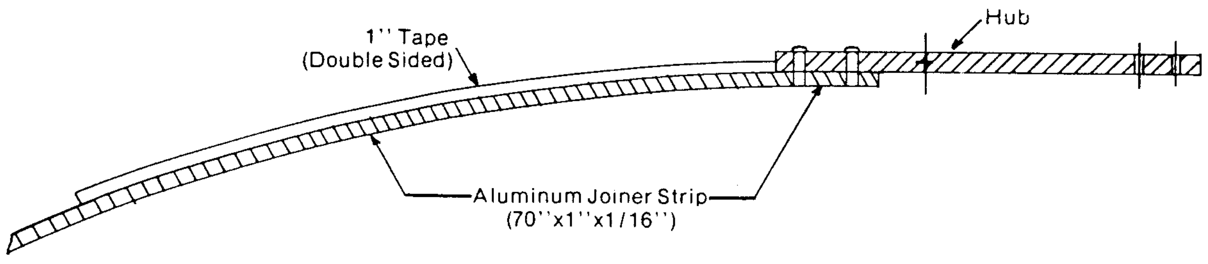


Illustration IV-F

Cut the upper joiner strips (66'' x 1'' x 1/16'') and apply double sided tape to one side, leaving the protective covering on one side just as you did for the lower joiner strips (**illustration IV-f**).

When installing the petals onto the joiner strips work accurately and carefully because the double sided tape is very sticky and difficult to remove once it has made contact.

Notch the narrow end of the petal to fit **between** the rivets on the hub center. It is also necessary to notch each corner of the wide ends of the petals to fit around the clamps which secure the joiner strips to the perimeter rod (**illustration IV-g**). Place the petal on the lower joiner strips and slide the end **underneath** the outer perimeter rod (**illustration IV-P**). Check the fit by making sure the petal does not overlap the joiner strips by more than half the width. **Ideally** you will end up with a 1/16'' gap **between** adjacent petals. If you do not, mark corrections and trim. If the fit is satisfactory lift out the petal, remove the protective covering from the double sided tape on the lower joiner strip and reinsert the outer edge of the petal underneath the perimeter rod. Then with one hand underneath the joiner strip and working from the outside towards the center, carefully smooth the petal onto the joiner strip.

PETAL TEMPLATE DIMENSION CHART TABLE IV-A

LENGTH	MID-POINT	WIDTH
2	.40	.80
4	.67	1.33
6	.88	1.75
8	1.13	2.25
10	1.38	2.75
12	1.67	3.33
14	1.90	3.80
16	2.20	4.40
18	2.50	5.00
20	2.75	5.50
22	3.00	6.00
24	3.30	6.60
26	3.58	7.16
28	3.83	7.66
30	4.08	8.16
32	4.38	8.75
34	4.67	9.33
36	4.90	9.80
38	5.13	10.25
40	5.38	10.75
42	5.58	11.16
44	5.83	11.66
46	6.10	12.20
48	6.30	12.60
50	6.55	13.10
52	6.80	13.60
54	7.00	14.00
56	7.25	14.50
58	7.45	14.90
60	7.67	15.33
62	7.88	15.75
64	8.05	16.10
66	8.25	16.50
68	8.45	16.90
70	8.67	17.33
72	8.90	17.80
74	9.17	18.33
76	9.38	18.75

To make template: Plot points every 2". Lay measuring tool perpendicular to the "Datum Line" at the 2" mark. Line up "Mid-point" measurement with the "Datum Line". Make a dot at "0" on your paper (below the line) and another where the "W" measurements falls (above the line). Do this for every value of "L" and connect the dots to form the template sides. The sides curve outward slightly to compensate for bending the pieces into a parabola. The drawing does not show the notches for the rivets, but you will have to include them when you make your petals.

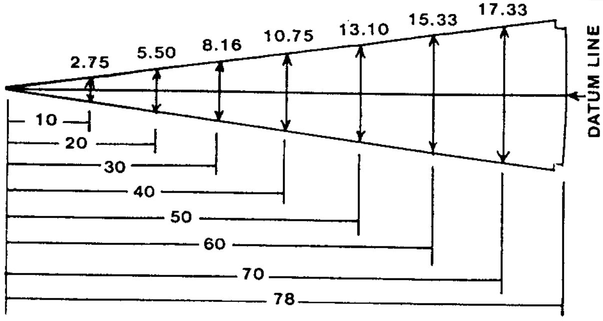
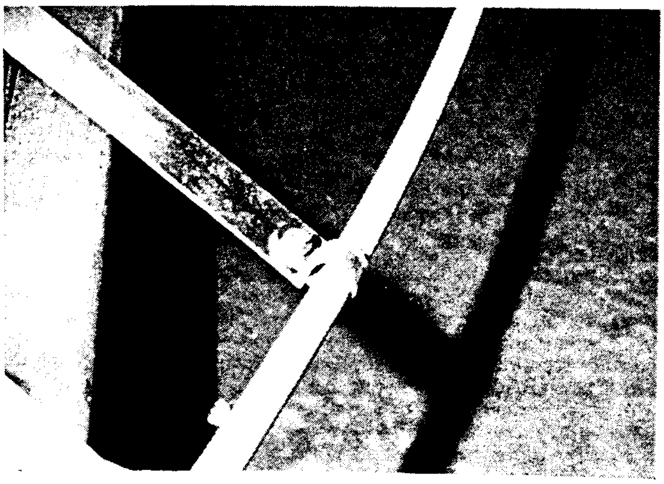


Illustration IV-g

The reason for the emphasis on not exceeding one half the width of the joiner strip is that **a small error on each of the twenty-four petals could easily add up to the width of a joiner strip and you would end up with your last petal not lining up at**



Lower jointer strips attached to perimeter rod with mounting clamps.

all with the last joiner strip.

Continue attaching the petals until the entire dish is covered. Now the upper joiner strips can be attached to the petals. Remove the covering of the tape from a joiner strip. Work from the center to the outer edge of the dish smoothing the joiner strips over the joints of the petals. Be very careful not to bend the petals in any way as this will cause distortion and stress. In this fashion attach all the upper joiner strips around the dish.

The next step is to carefully roll the ends of the aluminum petals around the perimeter rod. To do this it is necessary to make four cuts in the edge of each petal to enable the petal to conform the shape of the perimeter (**illustration IV-g**). First, with your fingers bend the aluminum over the **top** of the perimeter rod until the edge is parallel with the petal. Then using pliers or vice-grips work the aluminum edge until it wraps around the perimeter rod. Do not pull the aluminum too tightly or you will deform the petal. Continue for each petal until you have a neat looking rolled edge (**illustration IV-h**.

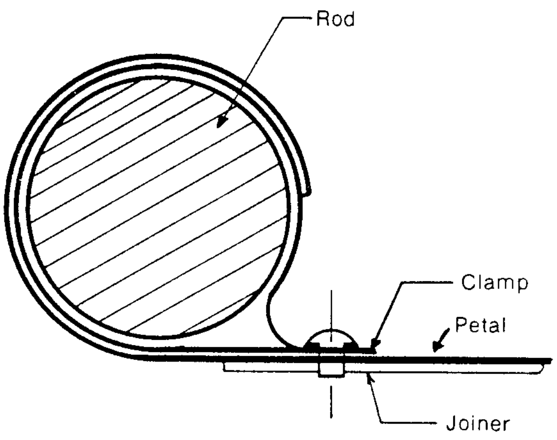


Illustration IV-H

In preparation for fiberglassing clean the whole surface of the dish with Varsol to remove any dirt and oil which could prevent a good bond.

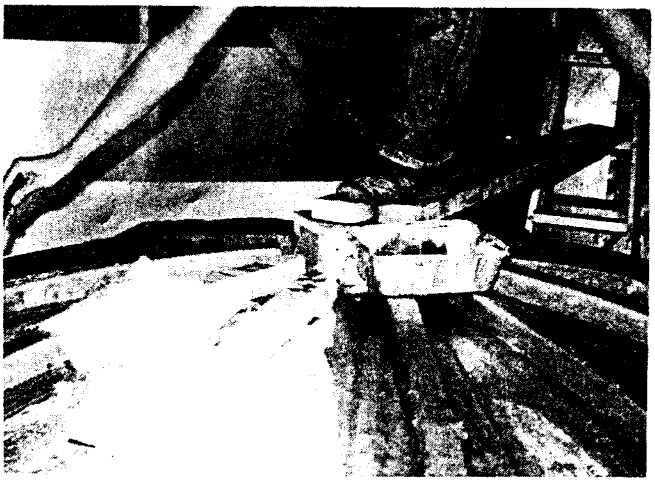
There are two methods of applying the reinforcing ribs and the fiberglass backing. The photos used in this chapter show **method #1** being used. In this method a layer of fiberglass is applied **directly on the back of** the dish. Then the reinforcing ribs are cemented and the wooden mounting blocks are cemented to the layer of fiberglass. After this a second layer of glass is applied. This method probably makes for the stronger dish. **Method #2** entails cementing the reinforcing ribs **directly to the aluminum** on the back of the dish **after which** a layer of fiberglass is applied to the whole assembly.

Next, you must glue the reinforcing strips to the back of the dish. The reinforcing ribs must be cut and contact-cemented onto the back of the dish with the six wooden mounting blocks installed (see photo). The ribs are cut from 4' x 8' sheets of 2'' thick Urethane foam (**not** Styrofoam which will **dissolve** upon contact with fiberglass resin). These ribs are 2'' x 2'' and can be cemented to the aluminum with ordinary contact cement. The dimensions of the pieces are shown in **illustration IV-O**. Also see photos.

We are now ready to bond the ribs to the back of the dish with fiberglass. Mat fiberglass cloth is used because it is generally more flexible and will conform to the compound curves. Cut twelve pie section shaped pieces of the fiberglass mat to fit between the rib sections (see photo). Then cut out rectangular pieces to fit over the rib sections. It will be necessary to cut slits where the mat fits against the sides of the ribs. This will allow the mat to follow the curve of the ribs without wrinkling. The same type of slits will be necessary for the pieces covering the perimeter ribs. Trimming may be necessary. **Just be sure to let the pieces overlap by three or four**

Wooden mounting block reinforcing installation.

Center hub reinforcement (shown glassed over).



Reinforcing rib placement during fiberglassing.

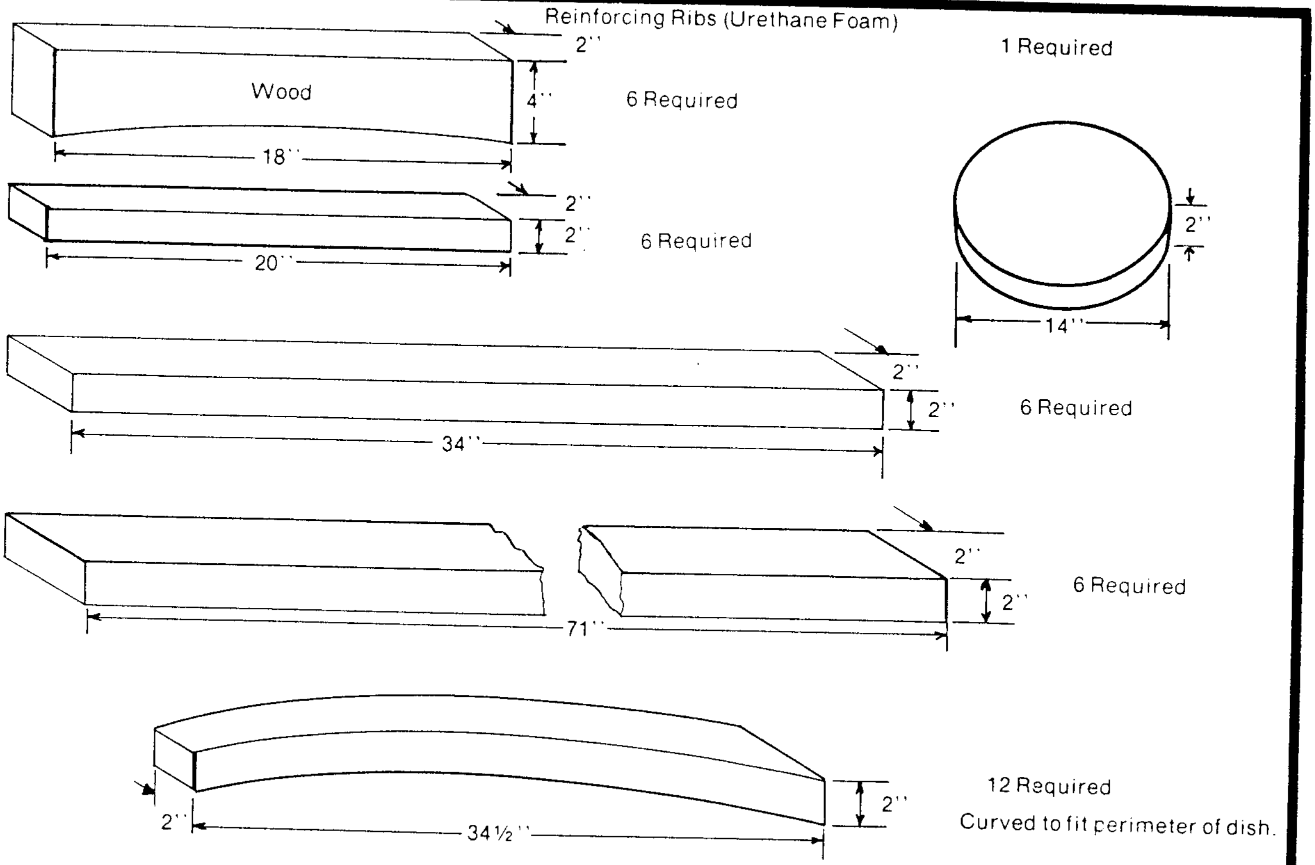


Illustration IV-O

inches. A double layer of the mat is recommended **over the six wooden mounting blocks** and the pieces should overlap by a minimum of 12''.

Use one inch roofing nails to hold the mat onto the Urethane ribs while applying the resin. Just press them in as if they were thumb tacks. Make sure that the mat fits closely to the ribs in order **to eliminate air pockets** between the dish and the fiberglass.

Now you are ready to apply the resin. Use plenty of resin and make sure it soaks completely through the mat to create a good bond. Throw-away aluminum trays (the kind used for storing frozen foods) and 4'' paint brushes will work well. **Mix only the amount of resin that you can apply within the drying time.**

There is no secret to fiberglassing. Just keep air bubbles to a minimum and don't let the resin dry on your brush.

ADDENDUM FOR A 10' DISH

If you have decided to build a 10' dish, there are a few changes required. The perimeter rod must be installed twelve inches from the outside edge of the form (see Chapter 3) and all measurements of the joiner strips and petals must be reduced by twelve inches (**illustration IV-f**).

PAINTING THE DISH

See Chapter VI for advice on painting the dish.

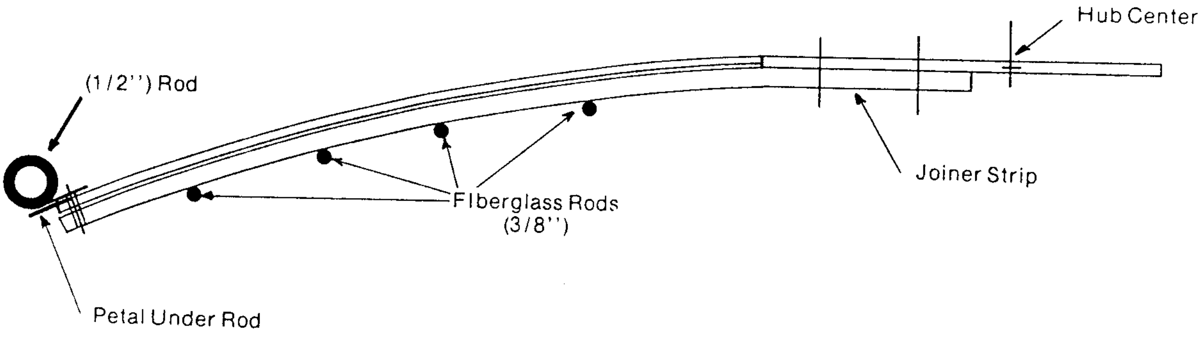
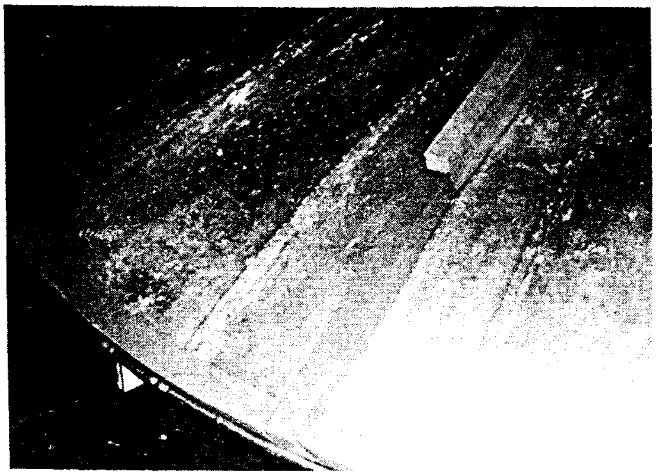


Illustration IV-P

MATERIALS LIST
DISH REQUIRMENTS

Aluminum	•24 pcs. 1''x1/16''x73'' utility aluminum. •24 pcs. 1''x1/16''x69½'' utility aluminum. •6 sheets .020x4'x8' utility aluminum.
Fiberglass	•30 sq. yards 3 oz. Fiberglass mat. •10 gallons polyester resin. •1 qt. catalyst.
Urethane Sheets	•2'' thick 4'x8' sheet.
Special	•300' foam filled tape (''3M'' or equivalent) double-sided adhesive
Hardware	•100 pcs. 1/8''x1/4'' length pop rivets. •24 pcs. 1/4'' x 1/2'' machine screws with nuts and washers. •24 pcs. 1/2'' hose clips(illustration IV-H) aluminum.
Wood	•1 pc. 10' x 2''x4'' pine.



Petal edges and placement of reinforcing ribs and wooden mounting block.

Fitting fiberglass mat over reinforcing ribs.

BUILDING THE FEED

The feed consists of an aluminum tripod bolted to the rim of the dish, a rotor to turn the LNA feed, an assembly for setting the focal distance of the LNA mouth, and a feedhorn to **load** the dish which bolts to the LNA. We do not include the LNA in the feed but you must have one!

The feed mount consists of an aluminum tripod bolted to the rim of the dish and terminating at the apex with a 9"x1/4" thick aluminum disc (see photos).

Cut three pieces of .0625 thick 1-1/2" diameter aluminum tubing to a length of 72". This allows two inches to be bent over as a dish mounting flange.

Cut three pieces of .0625 thick 1-3/8" diameter tubing (which will slide nicely into the 1-1/2" tubing) to a length of 36". This will allow two inches for the rotor mounting flange.

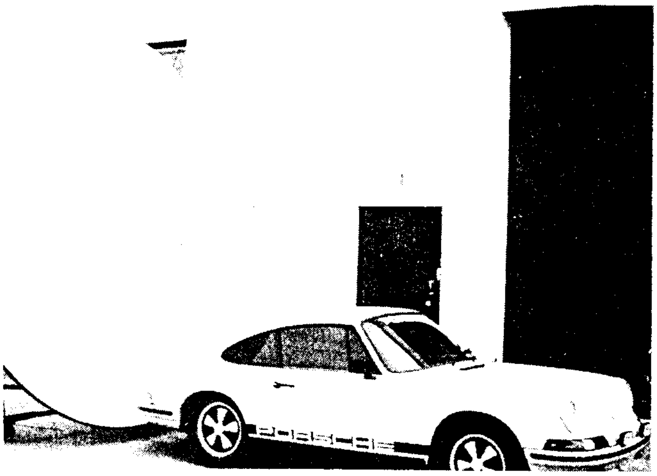
Take the three 72" (1-1/2" OD) tubes and flatten the last two inches of one end of each tube. Drill a 1/2" hole in the center of each flattened end and then bend the end to the appropriate angle. At the other end of each of the three pieces, cut a slot (with a hacksaw) of about 2" in length. This will facilitate clamping the inside of the tube to the outside one.

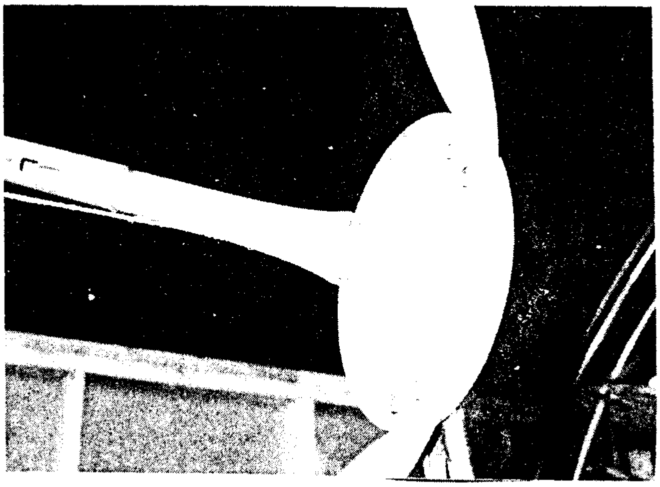
Take the three (1-3/8" OD) tubes and flatten one end of each in the same manner as you did the other tubes. Drill two 1/4" holes in each of the flattened sections. Slide each pair of tubing together (one short and one long) and clamp them with stainless hose clamp at 90" length.

Measure three equidistant points around the perimeter of the dish and drill 1/2" holes at each point one inch in from the edge.

Cut out the 9" diameter 1/4" thick aluminum plate for the rotor mount. Drill three pairs of holes spaced equidistantly around the perimeter of the plate 1" from the edge. Bolt the flattened tubes to the plate as shown. Bolt the other flattened ends to the holes drilled in the perimeter of the dish.

It will be necessary to adjust the length and angles of the legs to assure that the rotor plate is parallel to the dish and the





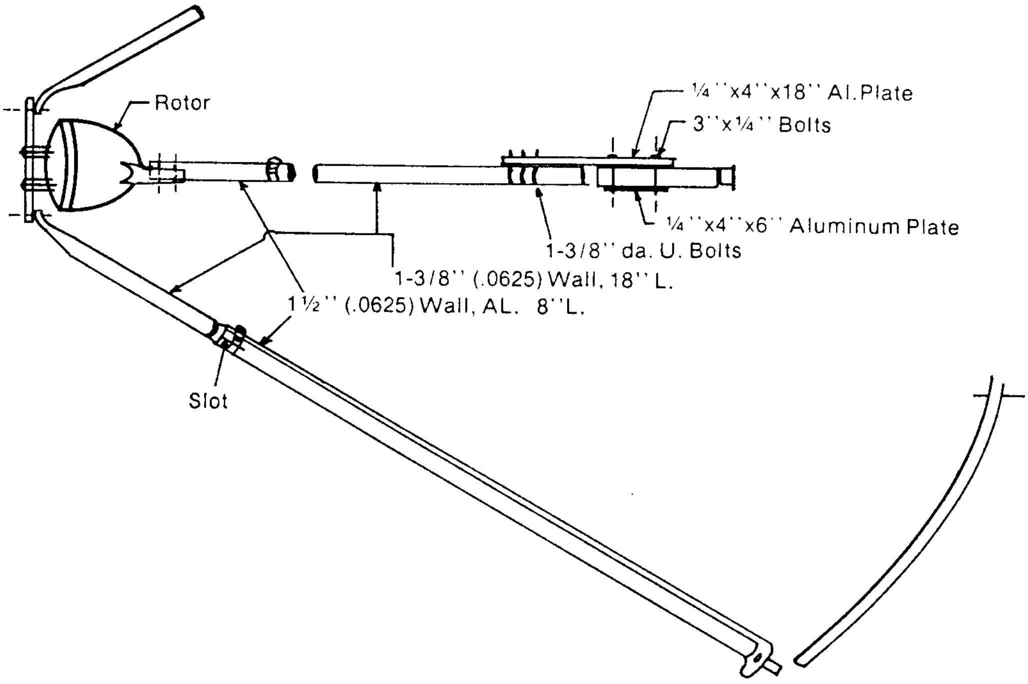

¼''x4''x18'' Al.Plate
Rotor
3''x¼'' Bolts
¼''x4''x6'' Aluminum Plate
1-3/8'' da. U. Bolts
1-3/8'' (.0625) Wall, 18'' L.
1½'' (.0625) Wall, AL. 8''L.
Slot

ILLUSTRATION V-C

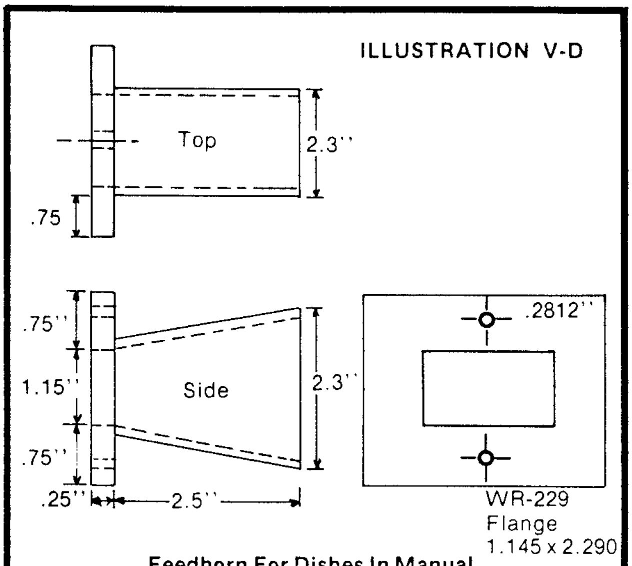
center axis of the rotor plate coincides with the origin of the dish.

You are now ready to drill the holes to mount the rotor. This mount is designed for the bell type rotor which mounts flat on a plate (see list of suppliers). Use of a telescopic aluminum tube which clamps into the rotor will allow focal length adjustment of the LNA. See **illustration V-C** for details on the contruction of the clamp which holds the LNA to the rotor shaft.

A feedhorn is a device which restricts the energy outside the beamwidth of the feedhorn from entering the LNA.

Transmitting horns have gain by focusing the energy leaving the mouth of the transmitting waveguide into a narrow beam. For all practical purposes the longer a horn is the more gain or tighter beamwidth it will have. The same is true for receiving horns. However, when a horn is used to feed (or illuminate) a parabolic dish **too much gain in the horn** will result in a **reduction of gain in the overall system**. The narrower the beamwidth, the smaller the amount of reflective surface the horn will illuminate thus lowering the gain of the dish. **Therefore**, after a point, **the higher the gain of the feedhorn, the lower the gain of the dish**. In fact, the waveguide above will have more gain without a feedhorn mounted!

If the waveguide has more gain without a feedhorn then why use one at all? It is used because noise is also a factor. This brings us back to Chapter II and our discussion of the figure of merit. This is the real story: the higher the figure of merit, the better the picture.



Feedhorn For Dishes In Manual

To get better soldering of feedhorn it would be necessary to angle cut the edges of the horn to 45°

$$G/T^\circ = \frac{\text{Antenna Gain}}{10 \log (\text{noise } ^\circ K)}$$

The 55% efficiency level for antenna gain, which is the same as saying the dish is illuminated to the point where the edges are 10 dB down from the center, is not a random figure. It was chosen because if you transmit into the dish this loading results in the highest EIRP. In a receiving situation where the antenna noise is low, the receiving capabilities of the antenna Therefore, it is good practice to load the antenna to the 10 dB down spot **for high look-angles** and in situations where there is no man-made noise. If your site exhibits a high level of noise caused by a low look-angle or man-made microwave interference, alternative antenna loading should be considered.

If you are designing your system to work at a look-angle below 15° you should consider shrouding the dish **or** going to a lower loading of the dish in order to maintain your figure of merit. Loading to the point where the edges are **15 dB down from the center** is a reasonable design criteria. Assess the circumstances **before** you construct your feedhorn. In general, those building the 10 foot dish will be in an area where they will have a high look-angle (above 15°) for satellite RCA F-1. The feedhorn described in this chapter will load a dish with an f/D of .45, such as the 10 foot dish described in this manual, to the point where the edges are 10 dB down from the middle. This is exactly what you need. The same feedhorn used with a dish with an f/D of .375, such as the 12 foot dish described in this manual, will load that dish to the point where the edges are 15 dB down from the center which is exactly what is needed for the low look-angles. If you are a purist at heart and have built the 12 foot dish for use at **high** look-angles, perhaps you might want to load your dish about 10 dB down at the edges. This can be accomplished **by taking about one inch off** the length of the feedhorn. You might also want to load the dish up a little more heavily than 15 dB down at the edges if you have opted for the shroud. By removing the feedhorn altogether from the LNA you can load your **12 foot** dish to the point where it is about 6 dB down at the edges and it might be an interesting experiment to check your location for guidance as to how to optimise your feedhorn.

There are two types of material that could be used for feedhorns. Sheet copper or brass of about .060'' to .100'' in thickness and the standard G-10 type of PC board of about .120'' thickness with copper on **both** sides. The PC board is easier to work with because it allows the pieces of the feedhorn to be cut out easily and the soldering to be done with a light weight iron.The brass or copper is hard to work with because it requires hacksawing and filing and a lot of heat to solder the pieces together. The double-sided PC board is recommended over single-sided because it allows the feedhorn to be soldered inside and out, giving it a little more strength. It might, however, be a good idea to use a single-sided piece of PC board for the flange mount part because it is not good to put copper onto the waveguide flange, usually aluminum, unless you are making a battery.

To make the feedhorn simply cut out all the parts on the plan included (**illustration V-D**)and assemble them with tape on the outside. Solder the inside of the edges **spreading as little solder as possible** because it creates loss of signals at microwave frequencies.

When the inside is soldered remove the tape and solder the outside using as much solder as you feel is required to give strength to the joint. Feel free to paint the outside of the feedhorn. **Do not**, however, **paint the inside**.

Use four bolts to attach the feed horn to the LNA. Ten bolts are not necessary to mount the **two ounce feedhorn** on the standard WR-229 flange!

MATERIALS LIST FOR LNA MOUNT

Aluminum	•1 pc. 1/4'' aluminum plate 9'' in diameter
	•3 pcs. 1½'' (.0625 wall) aluminum tube 72''
	•3 pcs. 1-3/5''(.0625 wall)aluminum tube 36''
	•1 pc. 1½'' (.0625 wall) aluminum tube 18''
	•1 pc. 1-3/8'' (.0625 wall) aluminum tube 18''
	•1 pc. 1/4'' x 4'' x 18'' aluminum plate
	•1 pc. 1/4'' x 4'' x 6'' aluminum plate
Hardware	•1 pc. 1½'' hose clamps (stainless steel)
	•2 pcs 1½'' U bolts and nuts
	•4 pcs. 3''x¼'' standard nuts and bolts
	•6 pcs. 1½'' x ¼'' nuts and bolts
	•3 pcs 3½'' x ½'' nuts and bolts
PC Board	•G-10 1/8'' two side 6'' x 12''
	•G-10 1/8'' one side 4'' x 5''

THE POLAR MOUNT

There are two types of mounts commonly used with Parabolic Dishes. These are the AZ-EL (Azimuth/Elevation) mount and the Polar Mount. The AZ-EL mount will allow the dish to be aligned to any specific spot in the sky. The disadvantage of this mount lies in the difficulty in aiming the dish at different satellites. This would require movement in two planes accomplished by two separate adjustment systems. The Polar Mount, however, tracks the entire satellite belt by moving the dish in one plane only and requires but one adjusting system. It lends itself easily to use with a motorized remote control system. Changing to different satellites can be accomplished sitting in your living room with a simple control box similar to a TV antenna rotor control.

To track the satellite orbit belt the parabolic dish must be rotated on an axis bore-sighted on the North Star.The angle of this axis can be visualized by considering the two extremes of a dish at the equator and another at the North Pole. The angle between ground level and the polar axis at the equator is 0° (the latitude of the equator). Therefore to track a satellite directly overhead the dish would lie flat on its back. To track a satellite twelve degrees further west (versus directly overhead) the dish would have to tip twelve degrees to the west on an axis running North/South.

In theory, at the North Pole* to track a satellite the angle between ground level and the polar axis is 90° (the latitude of the North Pole). The dish would be standing straight up on its edge and would point due south tracking the satellite. However, there would be an offset angle required as seen in **illustration VI-A. Without this offset angle** the dish's focused beam would completely miss the satellite. This offset angle varies as one moves between the equator and the poles. The formula for calculating the offset angle is shown below.

$$\text{OFFSET ANGLE} = \text{ARC SIN} \left(\frac{4000\,(\text{SIN LAT}^\circ)}{D + 4000\,(1 - \text{COS LAT}^\circ)} \right)$$

D = distance to the satellite from the equator.
4000 = radius of the earth.

Examples of the offset angle are given in Table VI-A.

The angle of the Polar Axis (between the ground and the dish) **is equal to** the degrees latitude of the site at which the dish is to be located. The only other significant parameter is to allow the dish to rotate on its axis enabling it to come down to the lowest look-angle required. To determine the minimum look-angle requires a complicated mathematical calculation. This information can be obtained from various sources(see list of suppliers).

The polar mount described in this manual (*) is the optimum in simplicity, strength and function.

It is basically a three-sided pyramid utilizing the advantages of triangulation to offer the lightest construction possible yielding the required strength. The mount is kept as simple as possible by fabricating it for the exact latitude of your own locale making any adjustment in the polar axis unnecessary. Therefore, the mount may be welded together in a one-piece unadjustable construction.

Adjustments of several degrees to compensate for errors in calculation or construction can be made by turning the mount on the foundation bolts or by setting bolts at different heights and using height adjusting nuts.

TABLE VI-A
Offset Angle At Degrees Latitude
[Northern Hemisphere]

Lat.	Angle in Degrees	Shim Dimension In Inches
0	0	0
5	.85	1.22
10	1.69	2.43
15	2.51	3.60
17.5	2.91	4.18
20	3.30	4.73
22.5	3.69	5.29
25	4.06	5.82
27.5	4.42	6.34
30	4.77	6.84
32.5	5.11	7.33
35	5.43	7.78
37.5	5.74	8.23
40	6.04	8.65
42.5	6.32	9.05
45	6.58	9.43
47.5	6.83	9.78
50	7.06	10.11
52.5	7.27	10.41
55	7.47	10.69
60	7.81	11.18
65	8.07	11.55
70	8.27	11.83
75	8.39	12.00

CONSTRUCTION OF THE MOUNT

Before starting construction of the mount, notice that all illustrations show the base triangle with North/South directions. These directions are not included to show final mounting position but to show the position during construction. Follow these directions carefully to enable the dish to rotate on its axis, rising in look-angle as it turns towards the south in the Northern Hemisphere. **However**, if you live in the **Southern Hemisphere**, turn the XY axis to face south.

The base is formed from three 8-1/2 foot pieces of 2'' x 2'' square tubing (1/4'' wall thickness). They are welded together at the corners to form an equilateral triangle. Then each corner is gussetted with a triangular 1/4'' thickness plate (see photo). This enables the mounting plates to bolt the mount to the concrete pad.

The piece that will form the axis of the polar mount (the pipe on which the dish rotates) should be constructed of schedule 80, 2'' OD nominal steel pipe for the twelve foot dish. For the ten foot dish, schedule 40, 2'' OD nominal will suffice.

At this time install the two pillow blocks on the pipe.

Next, cut a **12** foot length of this steel pipe and cut off one end to an angle equal to your location's latitude in degrees **(illustration VI-C)**. This is the angle of the polar axis. At this point make sure the base is level.

Now, with the assistance of a friend, butt the angled end of the pipe at corner X, parallel to side XZ (pointing up at an angle towards corner Z); **illustration VI-C**. While maintaining this angle, **pivot** the pipe on corner X towards corner Y until the included angle (W, Z, Y,) **is equal to** the lowest look-angle (in degrees) for **your** location.

These angles can be best checked with an inclinometer on the pipe (X, W). **This angle should equal the polar axis for your location.** The second angle can be checked by placing a straight edge on the **side** of the pipe near the top to the side of the base tube (XZ) **(illustration VI-C)**. Check this angle with an inclinometer.With the pipe properly lined up and held securely tack-weld the pipe to the base at corner X.

Now **temporarily** support the end of the pipe with a 2'' x 4'' wooden block. Check the two angles **again** and make any needed adjustments **now**.

***Actually, geostationary satellites do not 'reach' the North Pole; 'look-angle'' disappears at around 80-81° north and typically locations north of 65-70° have a difficult time ''seeing'' more than 1 or 2 satellites that are due south.**

*** For a more thorough discussion of the limitation of a polar mount, see STT's ''Satellite Navigator Manual'' by Stephen Gibson. Bottom line: Polar mounts are not as satisfactory as often represented!**

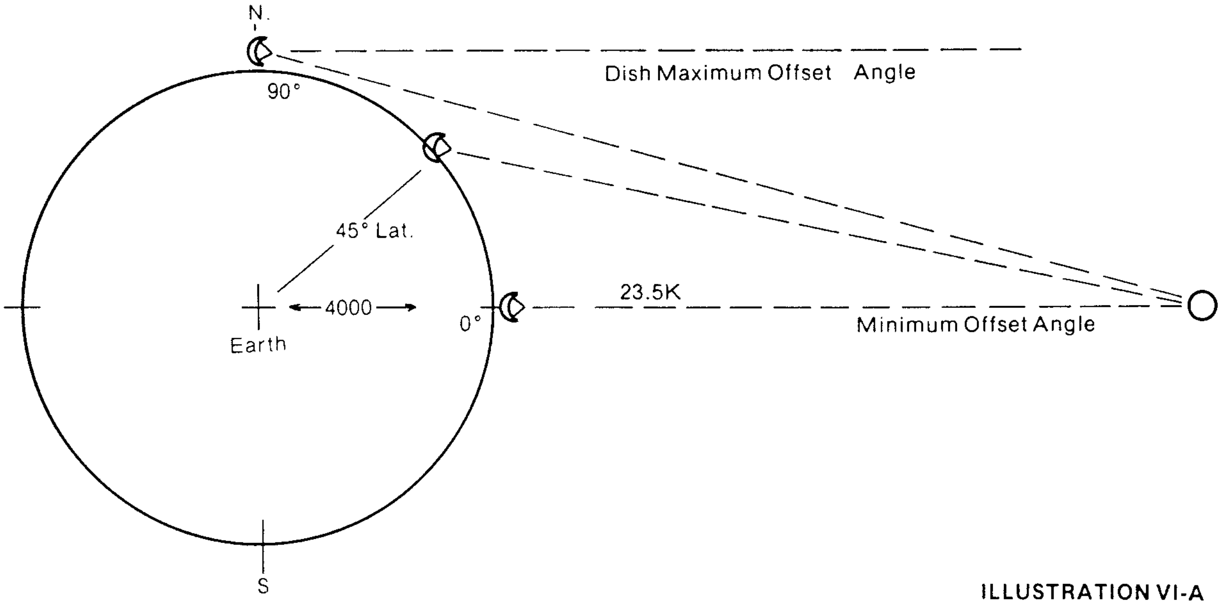
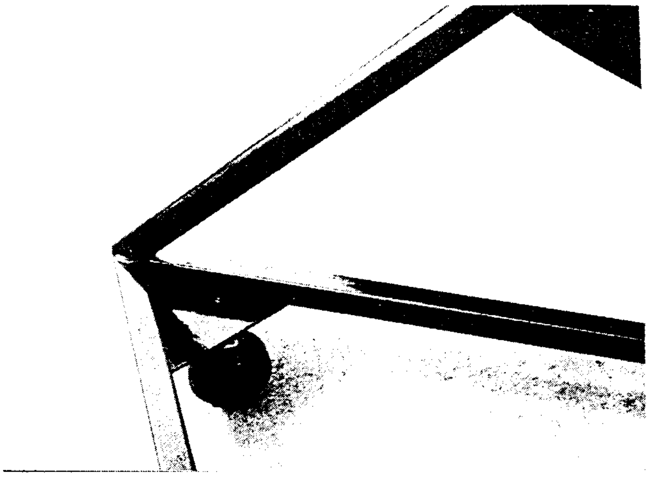
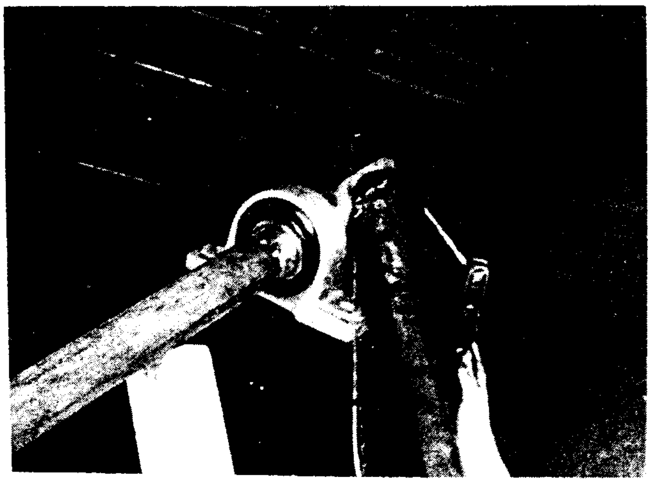


ILLUSTRATION VI-A



Base corners showing triangular gussetts.



Apex of mount showing bearings installed before welding.

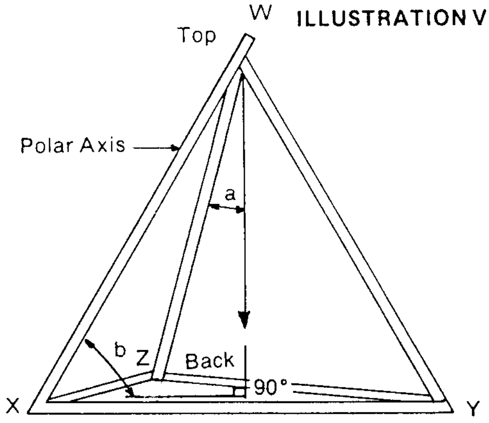


ILLUSTRATION VI-C

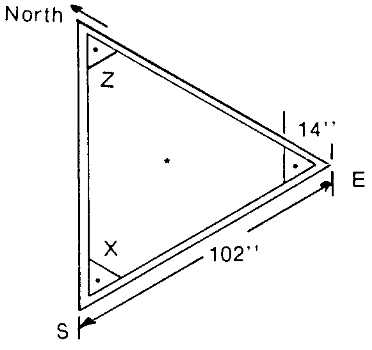


ILLUSTRATION VI-B

Measure from the top of the pipe (W) to corner Z. **Cut a piece of 2'' x 2'' tubing to fit.** Tack-weld this tubing at each end.

Do a final check of the two angles with the inclinometer. If everything is accurate, weld all the joints at each base corner. You will now probably have to tip over the base to enable you to weld the joint at the top. The mount is now ready to prime and paint.

The support frame is a six-sided structure made of 2'' x 2'' x ¼'' square tubing.

Take six pieces of the tubing and cut the ends at a 30° angle for a total outside length of 48 inches. Set up the six pieces on a level work area and butt the ends together to form a hexagon. Weld each joint (**illustration VI-f**).

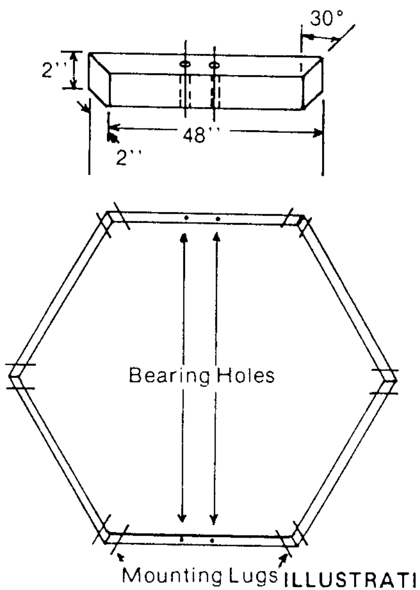
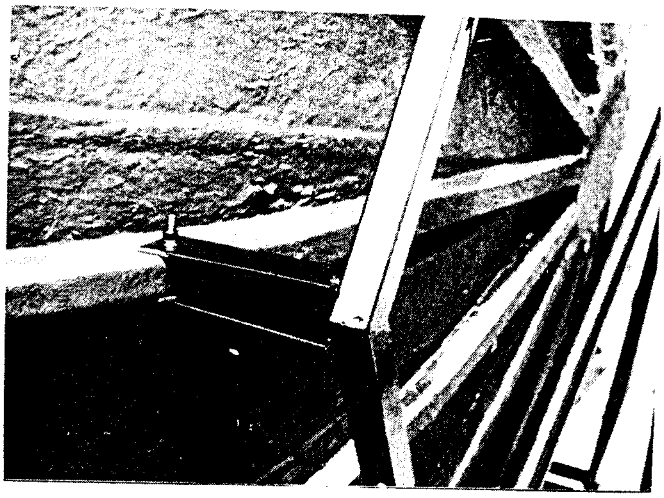


ILLUSTRATION VI-F



Dish support frame showing mounting lugs.

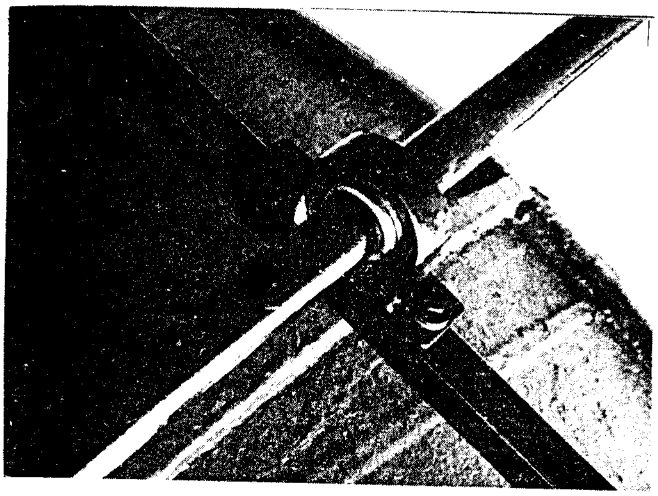
Now, you will need 12 pieces of ¼'' plate 10'' x 3''. These are the mounting lugs (**illustration VI-f**). Drill a ½'' hole 1½ inches from the end in each lug. Choose two corners of the hexagon (180° apart) and weld two sets of lugs on as per the photo.

In Chapter IV we suggested that the dish be left on its form after construction. This was to enable you to mount the dish support frame into position on the back of the dish with the mounting lugs astride the wooden mounting blocks. Be careful not to let the lugs sit on the back of the dish; use shims to hold it off. Be sure that the frame is level. Using the holes in the mounting lugs as a guide, drill right through the two mounting blocks and install the bolts and nuts tightly. The support frame is now bolted in position by only two lugs.

Take the four other sets of lugs, unwelded, and position them properly at the remaining corners. Drill the blocks and bolt the lugs in place. Now you can tack-weld the lugs to the support frame, making sure the frame remains level. If you have difficulty welding the lugs in this position unbolt and remove the support frame from the dish and finish the welding on the ground. The frame can now be primed, painted and bolted back onto the dish.

At this point you should make a shim which goes between the **upper** bearing and the dish support frame. For ease of construction this shim can be cut out of a block of reasonably hard wood, although steel or aluminum will work equally well. The thickness of the shim required for your location can be found in the **Table VI-A**: offset angles at degree latitude.

The final step is to drill the holes to mount the pillow blocks. These two holes should be drilled in any two **opposite** sides of the hexagon. You can now remove the clamps which held the dish to the form and remove it from the form. You will need the help of three or four people to position the dish for installing all the bearing bolts.



Pillow block mounting.

The mounted dish is now ready to be moved to its final position. But, you should paint the reflective surface of the dish and too at least prime the fiberglass back for protection against weather and sun. Use Zinc Chromate Primer (aluminum primer) on the aluminum petals and then apply two coats of a good **flat** white **exterior latex**. Red oxide primer will work nicely on the fiberglass portions of the dish. You will now have a very attractive and durable TVRO antenna system.

There are two types of concrete footings that can be used to anchor the dish at ground level. the first type is a concrete pad in the form of an equilateral triangle with side measurements of 9' x 9' x 9'. The pad should be about 10'' deep and a 1/2'' re-bar around the edges of the pad would be a wise addition. **A threaded rod** should be installed in the form at the appropriate **mounting points**. The pad will require approximately 3½ cubic yards of cement.

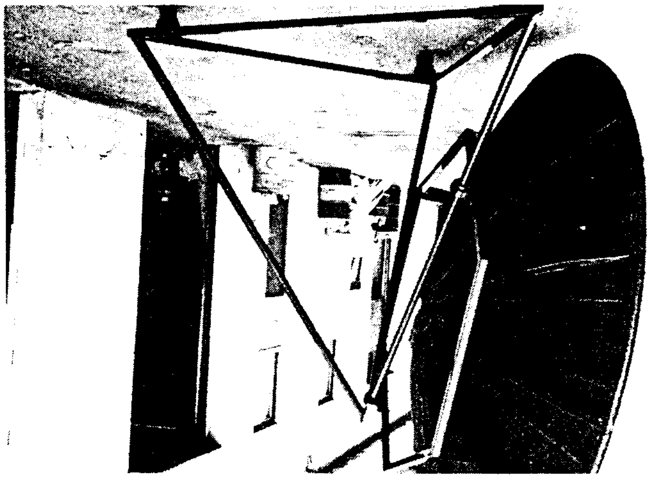
The second type of foundation consists of three **individual** cement posts forming an equilateral triangle. Standard round waxed cardboard forms are used (12'' diameter x 4''). Threaded rods are used for the three mounting points. The depth of these forms will depend on the frost level at your particular location. The posts will require approximately 1 cubic yard of cement.

The post foundation requires good soil support. The common 4000 lb. per foot type of strata is minimal for use with the posts. The use of posts is inadvisable on sand, soft clay, deep frost or high water table.

If you plan on mounting the dish on a roof-top you should seek professional advice on the mounting. Remember, the average dish has a wind area equivalent to that of a small sailboat. The forces involved are substantial, to say the least.

One last suggestion: check your positioning of the dish carefully **before** digging the foundation and pouring your cement. It is a good idea to bore-sight the North Star and actually drive stakes (on a north-south line) **through** the base of the mount where you will be placing your dish. If you already have your LNA and receiver you could check the television picture before securing the dish.

You may be **considering** raising the dish up in the air about 15' to give it a clear view. Be prepared to install a lot of concrete and steel support. A Canadian firm, The Wind Turbine Company of Canada, Ltd. at Elmira, Ontario, sells a tower that will support a 16 foot dish. The tower requires a base containing **30 cubic yards** of concrete for a tower 30 foot in height! You may not need this type of construction, but if you do you should be aware of the stresses involved. If you do decide to use a raised platform for your dish, **your feedback** on the project **would be appreciated.**



Completed Mount

Adding a motor to your mount will enable you to control the tracking of the satellites from your living room. The system originally envisioned was one which contained a motor gear reduction unit that would be sturdy enough to hold the dish in winds and control the motor drive unit in both directions from a remote location. It would ideally be a low voltage unit with some method of feedback for inside monitoring of the antenna position (similar to a TV rotor). Above all it would be completely waterproof.

The parts for this system are widely available since several companies make the needed linear actuators. Their only disadvantage is their cost. The cheapest source of linear actuators **I found** is Warner Electric Company in Beloit, Illinois. Their most appropriate model is the DCA-10JB-12. This is a twelve volt unit with a stroke speed of .86 inches per second. The unit requires 12 volts at 4 amps for power. Reversing the polarity of the power supply voltage will cause the unit to reverse direction. The actuator will take a static load of 1,200 lbs. which also indicates the maximum wind load pressure it can withstand. The price is $176.30 plus tax.

Try as we might we could not come up with a cheaper method for motorizing the mount · A piece of threaded rod put into a pipe with a nut welded to the top tended to rust and bind within **a month** in Montreal's climate. The biggest problem in designing the motor drive is weather-proofing.

The linear actuator meets all the requirements mentioned in the first paragraph except for providing feedback inside the house to register the position of the dish. The easiest way to accomplish this is to install a slider pot close to the spot where the dish support frame and the pillow block attach to the mount. By feeding a small control voltage through the slider pot a voltage proportional to the position of the antenna can be produced and fed back to an inside meter thus allowing the position of the dish to be monitored.

Because of the high cost of the actuator you may find it worth while to look for alternate sources of supply such as an electrical junk dealer or scrap yard. One source advertising linear actuators at a low cost is Princess Automotive Supply in

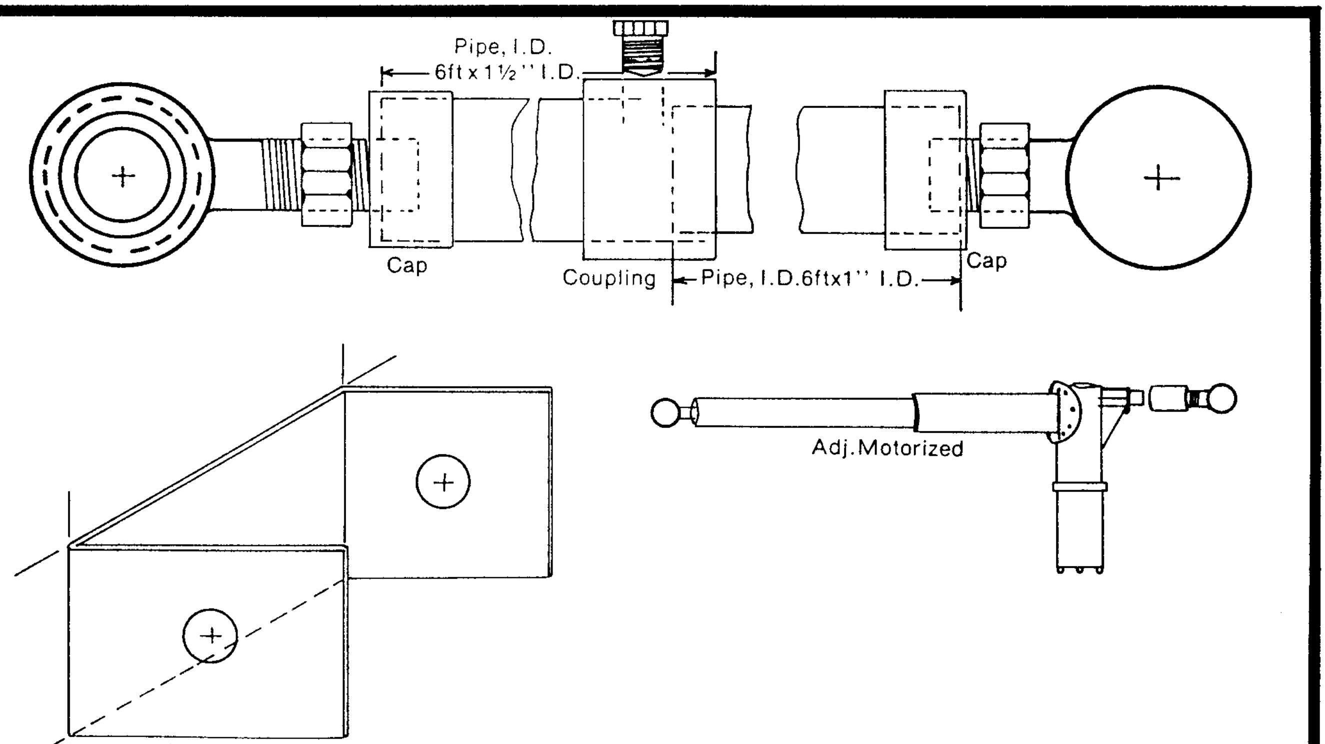


ILLUSTRATION VI-G

Winnipeg, Manitoba, Canada.

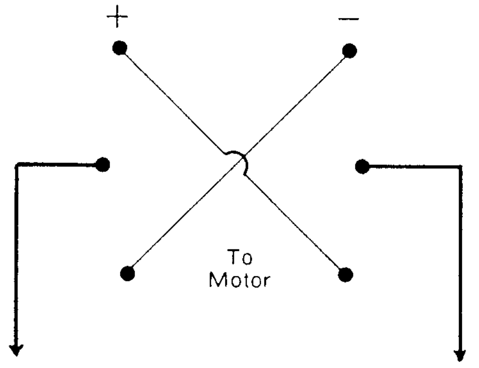
Because of their mechanical advantage you should use actuators with a stoke of 12'' and a thrust of at least 1,000 lbs.: **more would be better**.

Before mounting the actuator you must determine how much your dish must travel on its axis to cover the satellites you want to track. Pick a spot at the top of the tripod mount and the dish frame where the stroke of your actuator will give the required swing on the dish. The back leg of the tripod at the top gives the best mounting spot. At each of the mounting spots you have picked, weld or bolt a piece of 2'' steel channel. It is often wise to **bolt it** until you have **confirmed** the location.

In order to use the Warner Electric unit you must convert both ends of the unit to ½'' rod ends. At one end of the actuator the rod screws right in, but at the other end the drilled shaft must be fitted with a clevis so that the rod end will screw into it. If you have another type of linear actuator you will have to convert it to rod ends as best you can.

Mount the actuator to the channel pieces by passing a 3½'' bolt through one side of the channel. Add enough shims **to center** the rod end; add an equal number of shims **through the rod end** and pass the bolt through the other end of the channel.

Hook up your 12 VDC motor with 2 conductor 16 gauge cab-tire or similar wire and run it to your control box. Use a momentary double pole double throw switch and wire it as indicated.



ACTUATOR WIRING

The dish will drive with as little as 6 volts and with the decreased voltage the actuator will work much more slowly. I recommend that in addition to the motor drive you add another securing system such as the manual adjusting one described in the next paragraphs or aircraft cable type tiedowns which can be secured when a storm is approaching. Be prepared. It may be too late when a storm hits.

The suggested method of manual control is the ''one-pipe-inside-another'' method. Take a 1½'' pipe cap (all pipe fittings mentioned in this section are standard) and drill a hole in the **center** of the pipe cap so that a ½'' rod end can be mounted in it. Use bolts on both sides of the cap and set the rod end so that it sits at least one inch **out** from the cap (**illustration VI-g**). Repeat this procedure using a 1'' pipe cap. Take a six foot section of 1½'' pipe with both ends threaded and attach a 1½'' coupling to one end of it and tighten securely. Drill an 1/8'' hole through the coupling and pipe. **Enlarge** the hole to 29/64'' **and thread** with a ½'' 20 TPL tap. Fit the hole with a ½'' fine bolt, preferably with a dog end. Screw the 1½'' pipe cap onto the other end. Take a 6' piece of 1'' ID pipe and put the 1'' pipe cap on the end. Slide one piece of pipe into the other. The fit will be quite loose but this is purposeful to prevent binding or seizing from rust. Determine the lowest and highest spots your dish must adjust to and pick out a location where, when the pipes are attached to the support ring and the base of the mount, everything has clearance, and, the best possible mechanical advantage is obtained. Weld or bolt two pieces of 2'' steel channel as in the motorized mount description and bolt the rods in.

This completes the TVRO Parabolic Dish Manual. I hope that everything will go smoothly and that you will be satisfied with your results. I look forward to hearing your comments on the project. **Please fill out and mail in the questionnaire at the rear of the manual.**

MATERIALS LIST FOR POLAR MOUNT

Steel
- 3 pcs. 2'' x 2'' x ¼'' wall 8½' long
- 2 pcs. 2'' x 2'' x ¼'' wall 12' long
- 1 pc. 1.9'' OD nominal schedule 80 (12' dish)

OR
- 1 pc 1.9'' OD nominal schedule 40 (10' dish)
- 3 pcs ¼'' plate 14'' equilateral triangle.

Hardware
- 2 pcs Pillow block bearing 2'' ID
- 2 pcs. Bolts ¾'' NC x 5''
- 8 pcs. Washers ¾'' ID
- 2 pcs. Nuts ¾'' NC
- 2 pcs. Bolts ¾ NC x length determined by shim required for offset angle.
- 3 pcs. 1½'' hose clamps (stainless steel)

INDEX OF SUPPLIERS

INNOVATION RECOURSE fiberglas rods and double-sided foam tape.
4209 St-Christophe
Montreal, Quebec
H2J 2Y8

TOOLS REQUIRED

Dish & Form
1/4'' to 3/4'' electric drill
sabre saw
screwdriver
countersink bit for 3'' #8 wood screws
6 wood clamps (6'' C type)
hacksaw
french curve (variable gentle curve used in drafting)
roll of masking tape
2 adjustable wrenches
bubble level - (12'')
polar mount
welding equipment
cutting torches
grinding unit
drill
tap 1/2'' 20 T.P.I.
inclinometer
compass

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CATALOG
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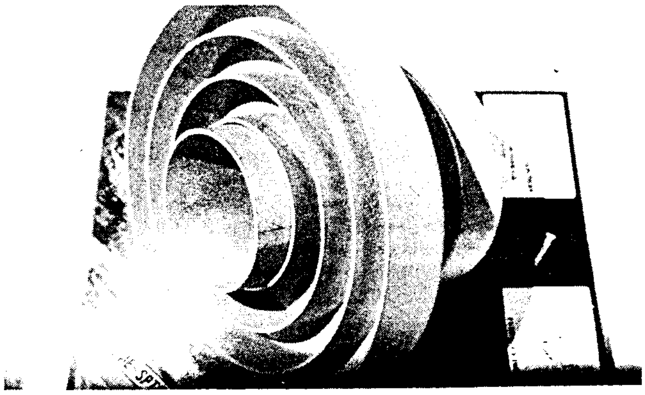
PUBLISHER'S NOTES:

Bob Cooper, Jr.

Satellite TV enthusiasts often ask me how we seem to turn out so many 'Manuals'. The answer is simple enough; there is so much for everyone of us to learn, from one another and from those who have expert knowledge.

The world of satellite communications is so new to us all that we do not have a vast storehouse of information tucked away to guide us in our endeavors. Those few people who do have all of this at their fingertips tend to be 'stuffy' and 'above' the trifling world of low-cost, private terminals. Furthermore, such experts typically are unable to communicate on a level which non-experts can comprehend.

So we are creating, through 'laymen' such as author Nelson Ethier, our own body of experts and our own fund of knowledge. I happen to look at a topic such as parabolic antennas (and virtually everything now in manual form from STT) as a 'college-level-cram-course' in the **new** world of satellite communications technology. I see thousands of people **now** reasonably well versed in this subject, each bringing to satellite TV his particular area of expertise or perhaps just his enthusiasm for a new field of endeavor. We attempt through these manuals to 'communicate' ideas, concepts and practical information. We usually succeed. I hope we have here although I recognize in my ninth or so reading of this manual that Nelson Ethier may be shooting over the heads of many readers who simply want to grab a hacksaw and some steel and start flinging debris. I resisted the temptation to 'edit-out' the brain-straining material in the front of this manual in the hope that you, if your brain was challenged by the first couple of chapters, **would perhaps come back to this one day** and realize how valuable an understanding of the "**why**" is when you are trying to practice the art of "**how**". I know, I dis-like math myself and I avoid formulas whenever possible. But I do try to understand why they work and then when I find myself unable to make a "how" work I have some way to go back to concentrate on the "why".



Chaparral's New 'Super Feed'

Not everything Nelson writes here is unequivocally true. There are many areas of shaded grey in the field of parabolic antenna design and both novices and professionals alike can find reason to question some of the statements in this manual. I **think this is healthy** because it will force you to re-examine the "why" a little more closely. If you understand enough of the "whys" one day you may be coming to STT with an idea for a manual of your own!

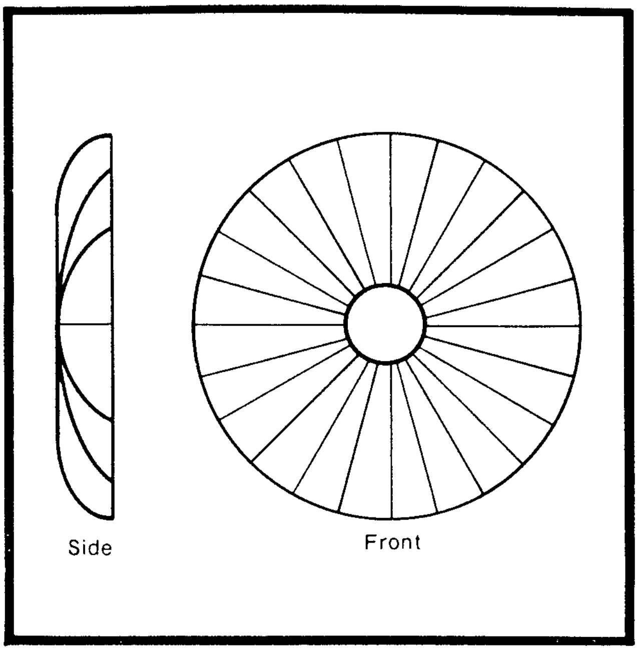
There is one recent development, reference the date of closure of this manual, which I feel must be passed along to the reader. Nelson's treatment of the feedhorn design is 'classic'; right out of the textbooks. Fortunately for all of us, some people have chosen to re-write the textbooks and very recently at that.

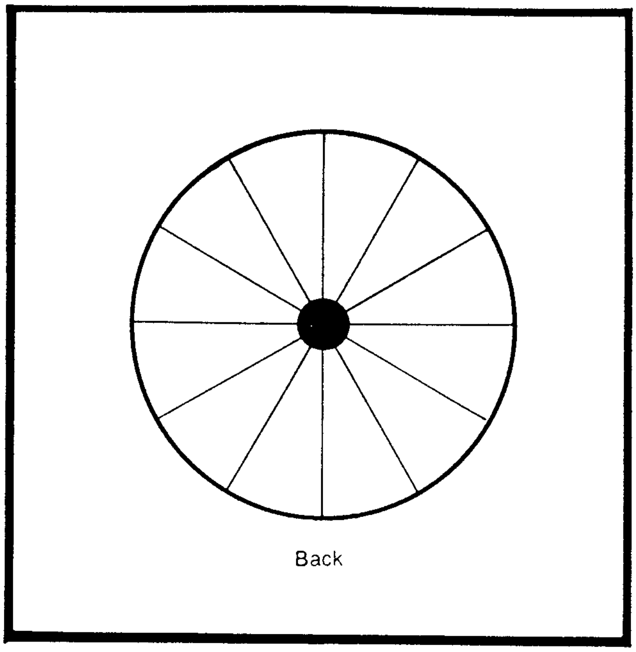
Regular readers of **Coop's Satellite Digest** will have noticed in the July 1980 edition a rather comprehensive report on a new feedhorn design worked out by Taylor Howard of Stanford and Bob Taggart of Chaparral Communications. Space does not allow me to tell you "why" here, only the bottom line "how". This new 'Super Feed' is very much superior to the classic 'horn feed'. How much better? We found no antenna we could test it on (and we had six available) with focal length to diameter ratios in the .35 to .5 region where the gain improvement of the parabolic antenna system was **less than** 1.0 dB. In one case it was almost 2 dB on an 11 foot dish!

Is this a plug for a new 'Super Feed Horn' from Chaparral Communications? No. It is simply my way of telling you that you can achieve better than the 55% efficiency assumed by Nelson Ethier in this manual; perhaps as much as 70% dish (aperture) efficiency, if you will include in your homebrew dish a Chaparral Communications 'Super Feed'. This manual, about high performance from a homebrew parabolic antenna, would be less than honest if we did not advise you of this. **Chaparral?** They can be reached at P. O. Box 832, Los Altos, CA 94022 (415-941-1555).

Finally, as Nelson suggests, let us hear from you. We are always looking for new manuals here at STT!

NOTES





WE WOULD LIKE TO HEAR FROM YOU

In order to improve the manual with each printing, we would like to know how you feel about it. Please complete the following questionnaire and mail it to:

Nelson Ethier
c/o INNOVATIVE RECOURSE
4209 St-Christophe
Montreal, Quebec
H2J 2Y8

QUESTIONNAIRE AND FORM REGISTRY

Filling out the questionnaire will aid those who will build a dish using future editions of this manual since it can be updated with your feedback.

1) Did you buy this manual in order to build your own parabolic dish or for general information?______________________

2) Are you satisfied with the information supplied on parabolic dish design? Please indicate any further design information that would be helpful. ______________________
____

3) Do you feel that you received good value for your money with this manual?______________________

4) Did you actually build a dish? If so, indicate your difficulties or parts of the text or diagrams that you felt were incomplete or inaccurate. ______________________

5) Are you satisfied with the performance of your home-built dish? ______________________

6) Which LNA and receiver are you using for your system and what is the general performance of your system like? ______
____

Please send this questionnaire to Satellite Television Technology, (P. O. Box G, Arcadia, OK 73007) and it will be forwarded to the author.

NAME: ______________________________

ADDRESS: ______________________________

CITY:______________ STATE______________ ZIP__________

FORM REGISTRY

Since the first edition of the Manual came out, author Nelson Ethier has been keeping a cental file containing names of those wishing to buy or rent forms built by other readers. So far there have been many request for forms, but no forms have been available. People who have them seem to have no trouble finding takers! There was a $5 fee for this service and Nelson feels that those who payed got their money's worth in information about the Manual which he sent them. No more names will be added to the file, but those who are in it will remain there and, should forms become available, these people will be notified. Anyone who has a form is encouraged to notify Nelson and he will in turn notify those in his file and "Coop's Digest".

IF YOU HAVE QUESTIONS OR PROBLEMS

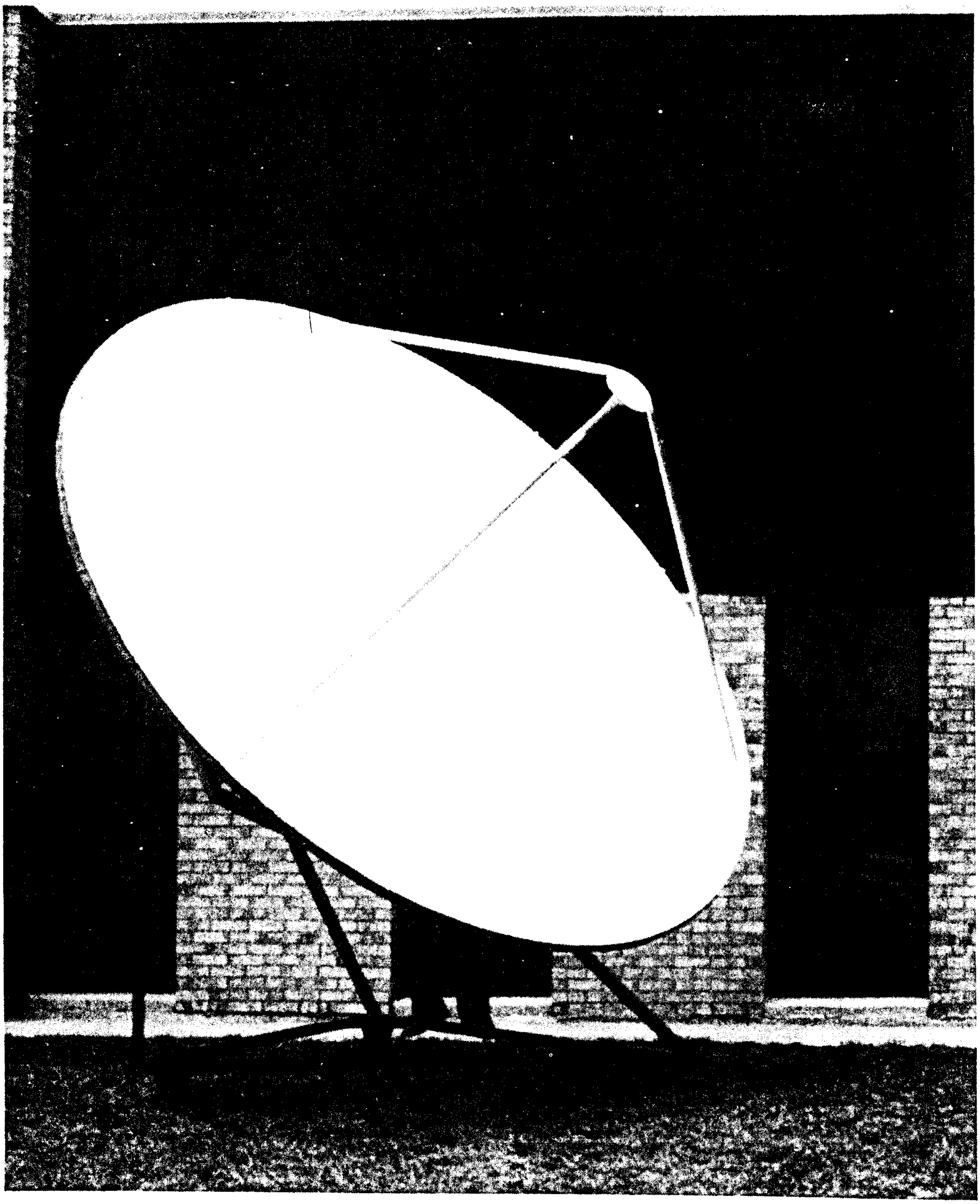
Nelson answers all telephoned inquiries at no charge, if they have to do directly with the Manual. (You must pay for the call, however!) Anyone sending a written inquiry and a cheque for $5 will receive current information on form availability, any updates to the Manual not in the 3rd Edition, and answers to specific questions concerning the Manual. Nelson will also be happy to help you with satellite television matters outside the scope of the Manual, but he will have to charge a consulting fee for this.

You may call him at: (514)527-4959 during business hours. He is often out of his office so don't be shy about leaving a message with his answering service! Write to him at the address printed above.

☐ I have a form for rent at the price of $______ for______months.

☐ I have a form for sale at the price of $__________.

☐ $5.00 enclosed (to Nelson Ethier); Please provide listings of individuals who wish to rent or sell a mold in "my area".



SECOND EDITION ERRATA

Judging from the feedback received from more than a thousand users of the first edition of this Manual many hundreds of parabolic antennas have been or are being built by private individuals. The astute reader will have noted a few errors in the first text. An even more astute reader will have noted changes in the 'production' system outlined here when you are planning to create several dozen (or hundred) antennas following this description.

The author is willing to assist users of this Manual with their problems provided they are problems relating to the creation of a **single** antenna of one of the two sizes described here. Requests for help in setting up production line techniques or re-designing for larger size apertures (20 feet is oft mentioned) are above and beyond the call of duty and would be considered on a one-to-one consulting basis.

Problem #1:

"Can I substitute material such as aluminum for the fiberglas rods called for without getting distortion on the rings?"

This is a poor substitution. Fiberglass rods have a feature that most other rods do not have; excellent memory. This means that a straight fiberglass rod always remembers that it is a straight fiberglass rod. It can be bent into a circle for a month and released and it will spring back straight again. This means the fiberglass rod is always exerting equal stress over every inch of its surface when bent into a circle and with a little help from the forms it provides an accurate radius.

The (fiberglass) rods are available from Fiberglas Canada in quantity and there should be sources in the US (anyone who knows specific of this is encouraged to supply the information to **CSD** where it will be published). **Comm/Plus** (3680 Cote Vertu, St. Laurent, Quebec, Canada H4R 1P8; telephone 514-337-7255) has been supplying the rods by trucking them across the US/Canadian border to New York state and then shipping them via truck common carrier to their destinations. This is a time consuming process which some enterprising US chap could improve upon!

Problem #2

"I have had a problem with bonding the aluminum and fiberglass resin. How come?

This problem occurs because of the type of aluminum sheet employed. The material specified was **utility grade** aluminum of 20 thousands thickness. This was specified because it has a surface much like 600 grit sandpaper; plus, it is cheap and is thin enough to form a **compound curve** when laid over the forms. If you cannot locate such aluminum sheeting and must buy the 'shiney' stuff you should sand the surface with 400 grade sandpaper (to rough it up). It is also a good idea to wipe the surface clean with a strong industrial solvent (Freon T.F. or methyl hydrate). If you are in doubt of the bonding ability, find out before trying the full surface! Take a small piece of the aluminum stock and some fiberglass resin and test it. Our first dish has been in service well over a year enduring snow, sleet, rain, freezing rain, hail, windstorms and the odd collision with low underpasses. The dish has suffered no degradation, no warping, no separations. It still performs as well as or better than commercial dishes. It fulfills all of the requirements of a microwave dish; i.e. it is parabolic shaped, round in the petal sections, accurate with no bumps or indentions and the surface is microwave reflective.

Suggestions for Improvement

The preceding Manual main section suggests driving the dish on the mount with a linear actuator. Frankly this may result in jerky movement because of poor geometry and fine adjustments are not easy to perform. This system has been replaced with a new system as shown in **photo A**. This system uses a hand winch and large garage door spring and it works great! One turn of the hand crank and the dish moves 2 degrees through our sky. A satellite can be received within plus or minus one degree of its assigned coordinates. One method of optimizing the dish portion is to turn the crank until the picture disappears and then turn the crank in the opposite direction until the picture re-appears and disappears again. Note these two positions (disappearance). Selecting a position half way between the two will optimize the dish pointing. If you mark the cable at the points where it enters the winch, for each bird, you will have a fast reference system for moving from bird to bird (**photo B**).

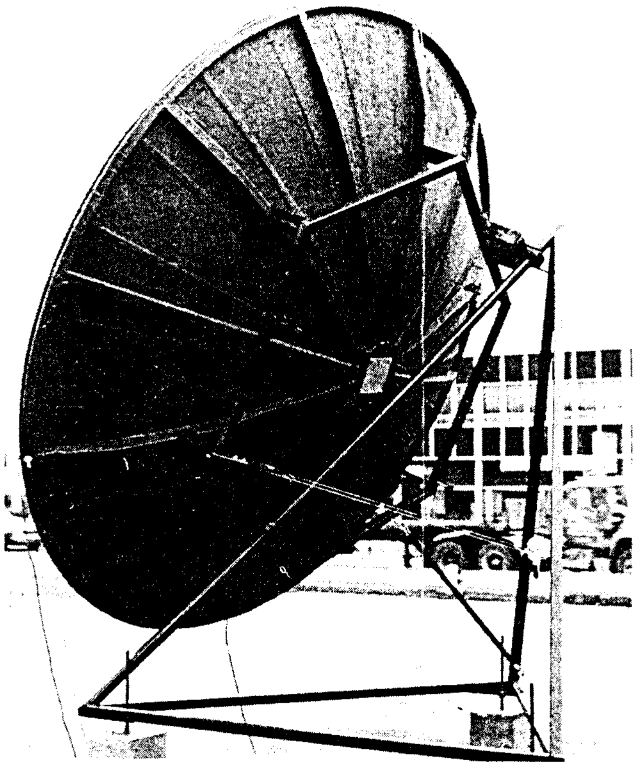


PHOTO A

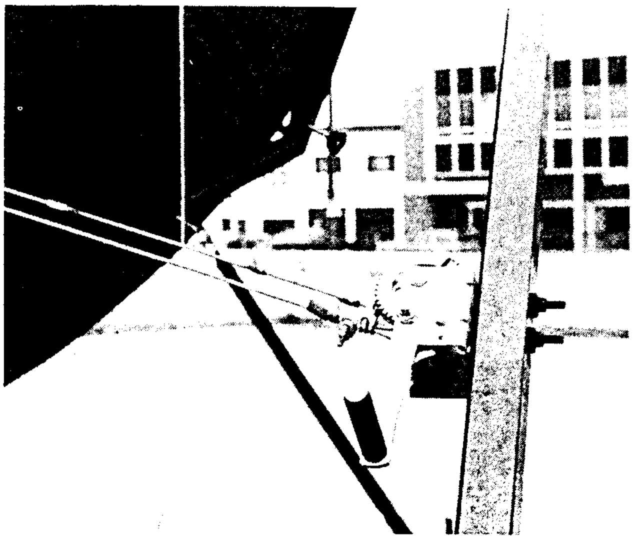


PHOTO B

The crank used is a rachet type commonly found for boat trailers and is generally available. The winch should be rated to at least 500 pounds. When it is used with the pulley there is a mechanical advantage of 2 to 1 which gives your system a 1000 pound load capacity. This will allow a wide safety factor since the pull on the dish is not likely to exceed 500 pounds.

When dealing with cables under tension **safety is a necessity**, not a luxury. Refer to **photo A** to ascertain the geometry of the pull. Bolt the winch directly through the mounting tube as seen in **photo B** using a pair of high quality

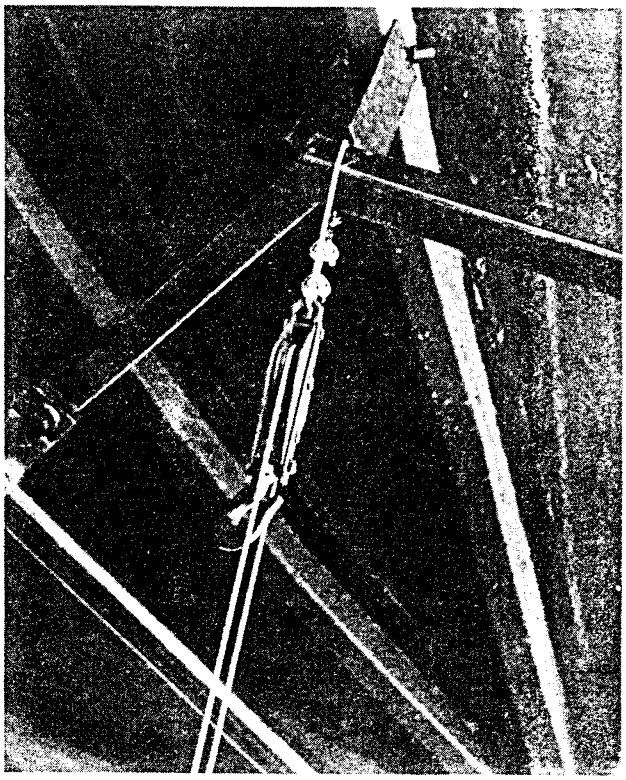


PHOTO C

3/8 inch diameter bolts around 3-1/2 inches long.

The cable used on the winch is 3/8'' aircraft cable with a tensile strength of 3000 pounds. Around 20 feet of cable is required. Attach a pulley of 3 to 4 inch diameter rated at 1000 pounds to the support ring so that it runs between the dish mount brackets. Note the use of **two clamps** for safety. Now run the cable through the pulley and then back to the base of the winch. Attach the cable (**photo A**) with two cable clamps.

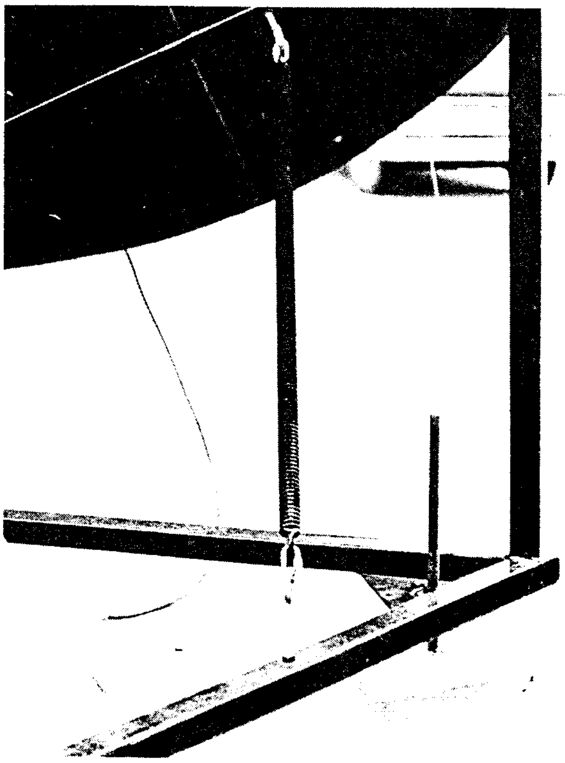


PHOTO D

Ascertain what your lowest 'look angle' will be. Mount the return tensioning spring (a 36'' garage door return spring) with a pair of 1/2'' eye bolts through the mounting tubing with a pair of 3/8'' chain links. Some grinding may be required on the eyebolts to get the chain links over them (**photo D**). Before drilling check that the geometry you have selected allows the spring to give minimal pull at the **lowest** look angle. Gravity will be pulling on the dish at this point so minimal tension is required. Note at the right hand corner of **photo D** the garage door stopper preventing contact between the mount frame piece and the dish. This will help prevent damage to the dish.

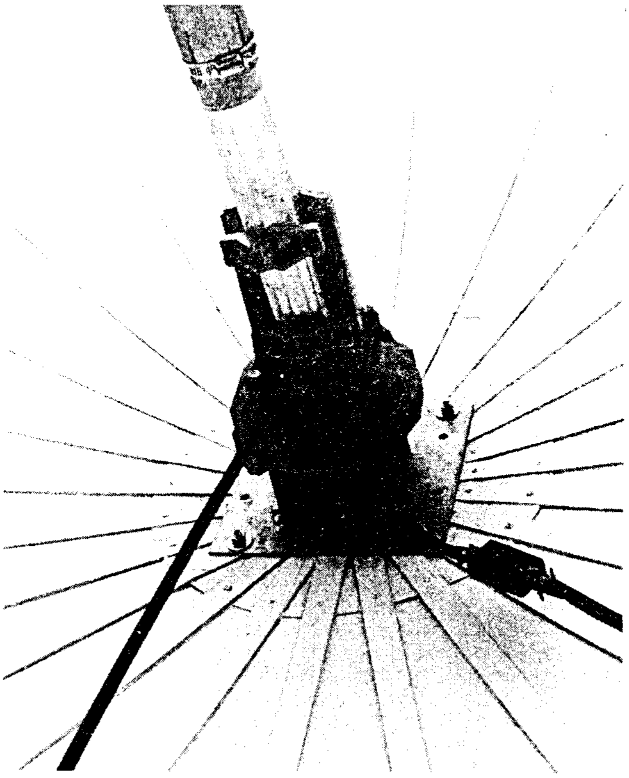


PHOTO E

This 'system' has a hidden advantage. The dish is now mounted in a suspension system rather than in a rigid system. In light of moderate winds the dish does not move at all; but in heavy winds it moves and **then returns** to its original position. This is desirable since it removes the stresses from the reflector and mounting assembly. Picture degradations typically last a half second or less during very heavy, buffeting winds.

Now this system can be motorized if you wish by adding a 500 pound electric winch (Sears Roebuck). Adding a 12 volt supply inside of your house allows you to operate the polar mounted dish from your TV viewing position.

Now the frame for the mount. The material suggested in the Manual proper may be heavier than required. A lighter gauge material **could** be used or a smaller diameter tubing with more triangulation at the point of stress. If the tubing were to be reduced to 1-1/2'' diameter the bearing could be smaller and this offers a savings. Some experimentation is in order here and feedback is recommended.

And the feed system. The tripod system described works but is is not the final answer. The tripod system described is slightly difficult to construct and with the weight of the rotor at the end there could be sag. We have worked with changes in this area. One concept is to mount the rotor on the dish proper and turn only the feedhorn and LNA (**photo A**). The second concept is to provide a bearing surface at the top of the feed support (see **photo F**) and adjustors at the bottom of the cable to the dish (**photo H**). This created a system that rarely requires adjustment and it is not prone to sage.

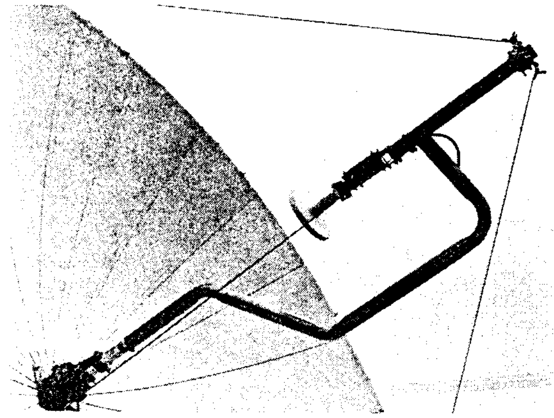


PHOTO F

If one follows this suggestion, here are some practical tips. We recommend a 'bell housing' type rotor such as the CDE AR 22XL ($65 US) or the solid state version (AR40; $80 US). To mount the rotor prepare two 8" square aluminum plates at least 1/16" thick. Drill matching holes in each corner of each plate. Bolt the rotor to the middle of one plate (see **photo E**). Place the plate with the rotor attached in the exact center of the front of the dish and drill through the corner holes of the plate to the rear of the dish. Now place the other plate at the back of the dish and line up the holes so that the two plates can be bolted together. Use 3-1/2" long by 3/8" heavy duty plated bolts and hardware. Tighten each of the four lightly (finger tight) and then when all are in place go around and tighten snug with a wrench (see **photo I**); but **not so tightly** as to crush the fiberglass section (see **photo I**).

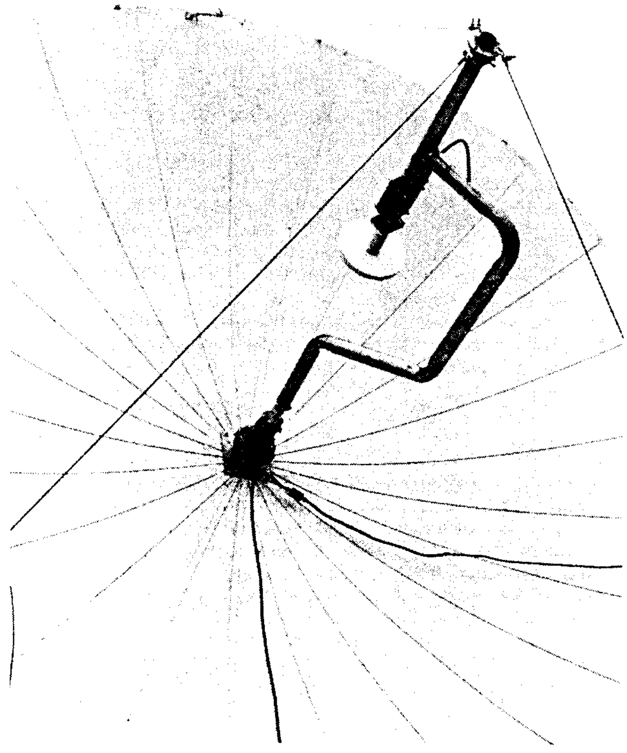


PHOTO G

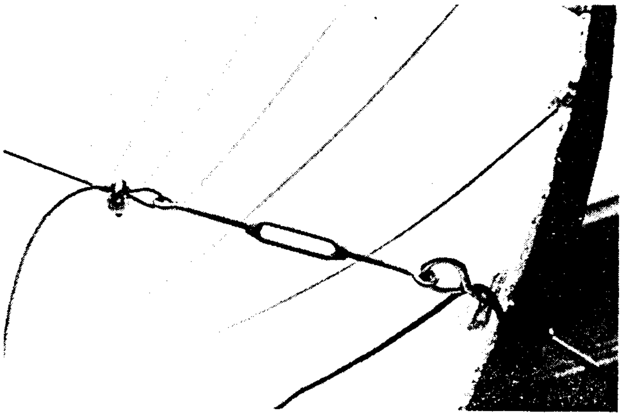
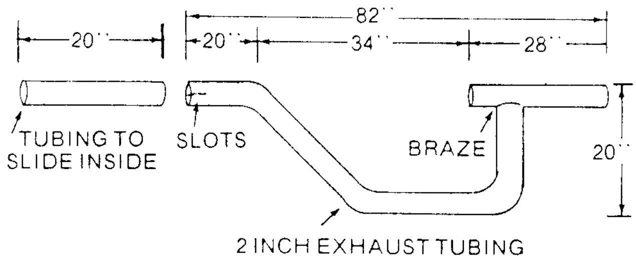


PHOTO H

The next task is to locate a muffler shop and find some 2" exhaust tubing. Have it bent into the dimensions shown in the **diagram** (one) here. Also show the metal bender **photo F**. If you have no brazing equipment you might get the shop to electric-weld the top tube in place. Be careful...the top tube must align with the bottom tube (this is critical). Slot the bottom of the tube as shown in the drawing, under the hose clamp. Obtain a piece of tubing that will slide into the muffler tubing; slide this piece into the main tube and temporarily tighten the hose clamp.



DRAWING 1

Mount the LNA onto an aluminum plate by whatever means is satisfactory for your LNA (see **photos F and G**). At the back of the LNA mounting plate use 2-1/2" U bolts to attach the mounting plate to the stub on the exhaust tubing. If you wish, run your Coax and LNA power cable through the exhaust tubing. Attach the feedhorn to the LNA and tighten all bolts making sure the LNA is mounted 'straight' on the plate. The feedhorn shown in the photo is the **Lindsay** unit available from Lindsay Specialty Products in Lindsay, Ontario, Canada. Adjust the tubing forward and backward at the rotor until the feedhorn is 52" from the surface of the dish (at center of dish). This is (on purpose) about two inches **shorter than** the focal point. If a 'pyramid' type of feedhorn is utilized, such as the one described in this Manual, the focal point is usually about halfway **inside** of the horn mouth. The feed can be optimized later by sliding back and forth until the maximum gain (i.e. best picture) is obtained.

You must install a top bearing at the top of the feed to center the feed support. You can either use a bearing that will fit inside of the tubing with a shaft sticking out (to which you

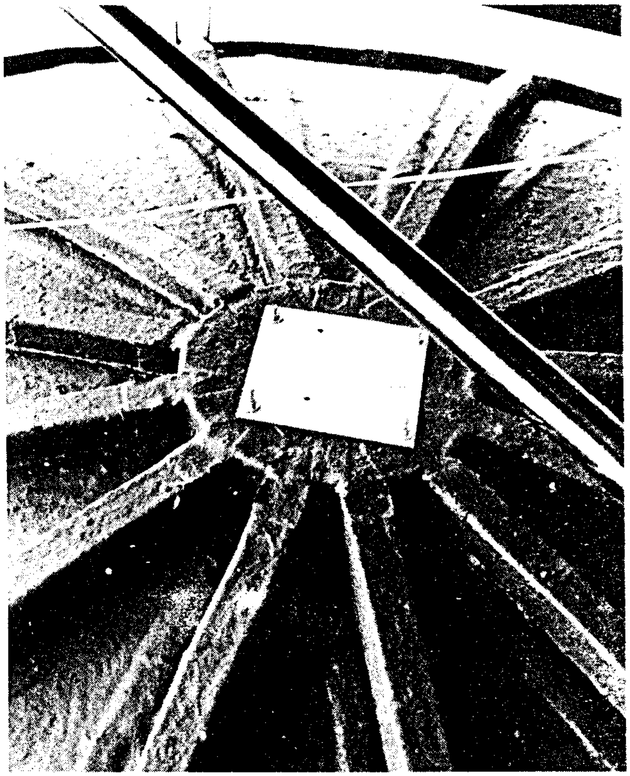


PHOTO I

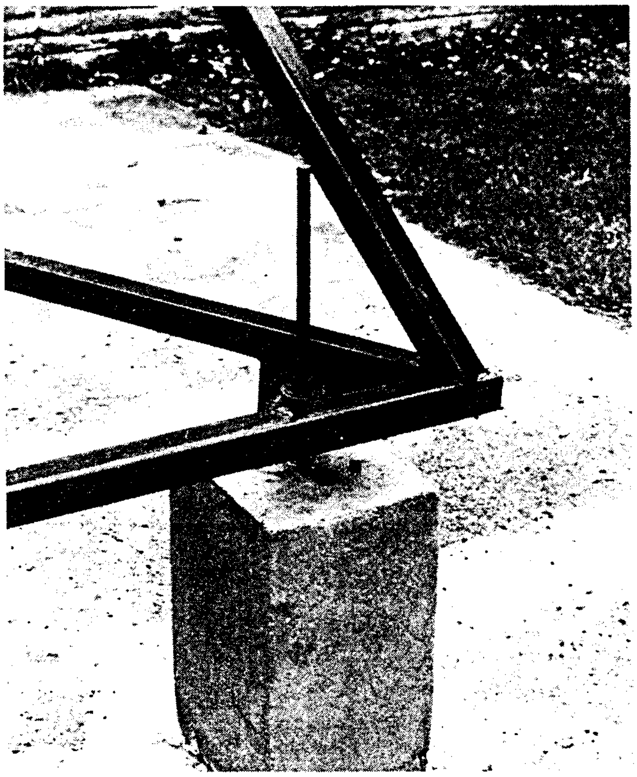


PHOTO J

mount the cables), as shown in the photo; one outside of the tubing. This is a thrust bearing intended for Trylon tower. To the bearing attach three separate guy wires as shown in **Photo G**. At three equally spaced intervals around the dish rim drill 3/8 inch holes. Insert into the holes 3/8" bolts making sure you sue an oversized washer on the back of the bolts to keep the fiberglass from being damaged. Hook a turnbuckle to the eyebolts as shown in **photo H**.

Carefully measure the distance of **each** cable and tighten each of the adjusting turn buckles until all cables are of the same length. This will center the feed fairly accurately. It is important to start out with the feed accurately centered.

Many do not realize that it is possible to receive satellite pictures with a parabolic dish with the feed **off center**; it simply works much like a Spherical antenna performs. However the geometry of a parabolic works out for a maximum gain with the feed precisely centered (at the focal point). After you have everything ready to go rotate the assembly with the rotor to make sure the feed support clears all of the guy wires and the bearing is working properly. Optimize the focal length by loosening the U bolts holding the LNA mounting plate and move the LNA closer to the dish until the picture disappears. Mark that spot. Now move the LNA outward from the dish until the picture peaks and then disappears again. Mark that location. The proper LNA position is exactly halfway between these two points.

Finally the matter of securing the dish to the ground. Perhaps one of the best ways of holding it down is to construct three concrete columns (see **photo J**). These should be at least 12" by 12" by 30" (deep) with a 3/4" threaded rod buried into the middle of the column. The columns fit under each of the dish corners with a nut and large washers on each rod.

Place the rod through a slot cut into each corner fillet. The slot must be long enough so the dish can be man moved about two inches in any of the three slots. Start off by using a carpenter's level to insure that the nut height on each rod results in the bottom rails being level. **When the dish is level** place a washer and nut over the top of the threaded rod and tighten down the nuts. You can see these in **photo J**.

For final adjustment you can move the dish and with a compass sight along the polar bar until the bar aligns with north (and south). Don't forget your local magnetic correction factor. If you want to be more precise, await a clear night and use the same polar bar to align to the North Star. This is the only adjustment you need to make for your polar mount; if the polar bar sights in line to the North Star you are close enough to accurate to tighten everything down and move on to more complex problems.

Now, having done this if your polar mount will not track the full Clarke Orbit Belt birds accurately you need to check the dimensions of the spacer between the upper bearing and the polar bar. This Manual deals with this in some depth referring to this as offset adjustment for latitude. If you are still having problems, re-check your feed for precise centering. When you are happy with the tracking of the dish it might be a good idea to then pour a six inch thick pad around all of the perimeter of the three columns to insure that if the dish moves after that point it moves as a unit!

As always I encourage the feedback of Manual users and hope to hear of both your problems and successes since we all learn by sharing our experiences.

Nelson Ethier

PROBLEM

Q. I left my form out in the sun and the whole thing buckled - what happened?

A. Fiberglas Canada says their polyester resin rods are stable up to 150°F. Maybe you used rods made with epoxy resin which would have a lower temperature failure point, especially when stressed.

Springwood Instant Print Pty. Ltd. Phone: (047) **51-6119**; Fax: (047) 51-1745